AU/AFF/NNN/2007-04

AIR FORCE FELLOWS

AIR UNIVERSITY

DEPARTMENT OF DEFENSE ENERGY STRATEGY

TEACHING AN OLD DOG NEW TRICKS

by

Gregory J. Lengyel, Colonel, USAF

A Research Report Submitted to the CADRE/AR
In Partial Fulfillment of the Graduation Requirements

Advisor(s):
Dr. Peter W. Singer
The Brookings Institution

Mr. Larry G. Carter
College of Aerospace Research, Doctrine and Education

Maxwell Air Force Base, Alabama

April 2007

Distribution A: Approved for Public Release; Distribution is Unlimited

Report Documentation Page

Form Approved
OMB No. 0704-0188

Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.

1. REPORT DATE **APR 2007**	2. REPORT TYPE	3. DATES COVERED **00-00-2007 to 00-00-2007**

4. TITLE AND SUBTITLE **Department of Defense Energy Strategy Teaching an Old Dog New Tricks**	5a. CONTRACT NUMBER
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Air University,Air War College,325 Chennault Circle,Maxwell AFB,AL,36112**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT
see report

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**74**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

Disclaimer

The views expressed in this academic research paper are those of the author(s) and do not reflect the official policy or position of the US government or the Department of Defense. In accordance with Air Force Instruction 51-303, it is not copyrighted, but is the property of the United States government.

Contents

Illustrations

Preface

As an Air Force helicopter pilot I have been an energy consumer for most of my career, and I am personally responsible for burning an estimated 1.1 million gallons of jet fuel during my 3,800 flight hours in the UH-1N and MH-53J/M aircraft. I have often been forced to conserve fuel as a necessity for accomplishing specific missions but never because energy was an expensive or a finite resource.

In 2006, in response to recent changes in the international security environment, the Brookings Institution launched its 21st Century Defense Initiative (21 CDI) within the Foreign Policy Studies program at Brookings headed by Director Peter W. Singer and Director of Research Michael O'Hanlon, with visiting military fellows serving as core members. The Initiative seeks to address some of the most critical issues facing leaders shaping defense and security policy in the coming century, including; *The Future of War; The Future of US Defense Needs and Priorities;* and *The Future of the US Defense System*.

In recent years I've become increasingly interested in the growing problem of United States dependence on imported oil. When selecting a research topic for this military fellowship I could think of no more critical issue facing future military leaders than energy security.

I would like to thank my advisors from the Brookings Institution and Air University, Peter W. Singer, and Larry G. Carter, for their guidance and assistance. I'd also like to acknowledge and thank Brookings Research Assistant, Ralph Wipfli, for faithfully forwarding to me anything energy related crossing his path.

Abstract

The United States has a National Security problem, energy security, in which the Department of Defense has a unique interest. The United States imports 26% of its total energy supply and 56% of the oil it consumes. The DOD is the largest single consumer of energy in the United States and energy is the key enabler of US military combat power. Huge energy consumption, increased competition for limited energy supplies, ever increasing energy costs, and no comprehensive Energy Strategy or oversight of energy issues in the DOD have created vulnerabilities. These include potential fuel and electricity supply disruptions as well as foreign policy and economic vulnerability. The DOD needs a comprehensive Energy Strategy and organizational structure to implement a strategy to improve National Security by decreasing US dependence on foreign oil, ensure access to critical energy requirements, maintain or improve combat capability, promote research for future energy security, be fiscally responsible to the American tax payer, and protect the environment. This strategy can be implemented through leadership and culture change, innovation and process efficiencies, reduced demand, and increased/diversified energy sources.

Chapter 1 – Introduction

Captain Steve Law was brushing his teeth when the phone rang. He'd been scheduled for an actual flying mission, a rare treat. Ninety percent of F-22 training was now conducted in simulators to save jet fuel, but one of the F-22 alert pilots was ill and he'd have to fill in for him. The Chinese would be flying a bomber past Honolulu in another one of their "friendship demonstrations," their tenth demonstration of 2020 and it was still only January.

It had been like this since Law's commissioning in the wake of the "9-11-2011" attacks, when Al Qaeda had celebrated the 10 year anniversary of their first attacks with strikes at various subways across the US and the bombings that took out the major Saudi oil production facilities. Captain Law remembers that day like it was yesterday. He was a senior at the University of Michigan and had already been accepted to Georgetown Law School. He was driving home in his Toyota plug-in hybrid to spend the weekend with his parents. His father was an out of work Ford Motor Company executive. After many lean years under chapter 11 bankruptcy protection, Ford had ceased operations in early 2011 and auctioned off all of its plants to Japanese auto companies. General Motors and Chrysler would suffer the same fate 2 years later. The American companies were simply overburdened with union health care costs, inefficient factories, and too far behind in developing energy efficient electric vehicles. World oil demand had been outpacing supply for too long, and when crude oil prices reached $120 per barrel in 2009, the US auto makers could not recover.

2011 proved to be an important year. After 8 years of occupation in Iraq, the last remaining US forces pulled out in June 2011 when Congress eliminated funding for the war effort. The well orchestrated Al Qaeda attacks in September that year completely shut down Saudi Arabia's oil industry and crippled world energy markets. The year closed with Iranian military forces crossing the border into Kuwait and Iraq in December. They quickly seized all of the major oil production facilities, and declared the Strait of Hormuz in the Persian Gulf as sovereign Iranian territory, closed to all other shipping. US military ground forces, their readiness and manning levels worn down from 10 years of constant fighting since 11 September 2001, mobilized for a return to the Middle East. US Air and Naval forces immediately began attacking Iranian forces in Iraq and Kuwait. The going was tough, but US forces started to make headway against the Iranians in the early weeks.

Everything changed when China got involved. In January of 2012, publicly blaming the war, the Chinese government tried to collect on their holdings of almost $1 trillion in US debt. The US government defaulted on payment and the value of the US dollar plummeted. The Euro became the main global currency. The collection though turned out to be a set-up for something even bigger. In the March of 2012, with absolutely no warning, the Chinese destroyed 70% of the US intelligence satellites in low-earth orbits, took down much of the US electrical grid through computer hacking, and deployed over 3,000 fighter aircraft to Iran. It was later revealed a bargain had been made for the support in exchange for exclusive buying rights to Iranian controlled oil.

Wave after wave of attack struck at US forces. By June 2012; 4 of the 11 US aircraft carriers were destroyed and 3 more had been damaged; and 14 of the existing 21 USAF B-2 bombers were shot down. USAF pilots in the venerable F-22 had achieved a remarkable 19:1

kill ratio, but by August 2012, after shooting down 1,745 Chinese and Iranian fighters, had gone from a force of 144 deployed aircraft to only 52. Other US fighters had a clear qualitative advantage and performed admirably, but were similarly overwhelmed by waves of enemy aircraft. Most importantly, fuel shortages began to cripple the US. The forces in the field and units back at home were almost immobile due to rationing, and the continued hackers' attacks on electrical grids made power a strategic commodity. Many units had been simply stranded in place. With the US and China on the brink of a nuclear exchange, and after Chinese naval and air activity began near the Atlantic and Pacific coasts of the US, a cease fire was declared on 17 August 2012. All remaining US forces returned from the Middle East to defend the homeland, and much of East Asia was abandoned to the Chinese.

More than the oddity of watching live Internet videos of troops in action and the subsequent Monday morning quarterbacking on the blogs, Law recalled the economic chaos of that period. Life in the US had changed forever. Even now, eight years after the war, GDP was still only at 60% of 2012 levels. The price of crude oil sky-rocketed to 190 Euros per barrel and, with the weak dollar, became unaffordable to most Americans. The whole of the US airline industry went under in 2013, and few Americans could afford to fly on foreign owned airlines. The US government nationalized domestic oil reserves, seized Latin American fields, and strictly rationed fuel to American consumers, with priority going to the government. But it was not enough. Were it not for the economic aid the Europeans still sent the US, things would have been much more devastating. A lot of Law's fellow officers grumbled that NATO was now profiting from the war it had sat out, but then again, beggars now couldn't be choosers. Many of the news stories compared it to the Great Depression. It seemed odd to Law that his generation would be going through just what his great grand parents had. So much for progress.

As he drove past the front gate and saw the wind turbines set up on the parade grounds and solar panels lining the barracks building roofs, Law recalled how strange the old attitudes had been towards energy had been. Back when he was in high school, people had started to talk about the importance of energy, what with the rising gas prices, shortages after Hurricane Katrina, and then President Bush's description of an "energy addiction problem." Even the military had dabbled in various energy efforts, such as researching a coal-based liquid synthetic fuel and making a few bases more efficient. But, as usually happens, they had all waited for the crisis to hit its worst before they had developed a true strategy and the institutions to make it happen on a scale that mattered. It was too bad. Captain Law would have liked to have been in a world where he could actually fly his jet a bit more often.

The United States of America has a National Security problem – energy security, in which the Department of Defense (DOD) has a unique interest. Energy is the life-blood of the US economy and dependence on imported energy is a looming national crisis.

Cheap and abundant energy has been the historical norm for American consumers and war fighters, and to most Americans energy is taken for granted. Electricity is as much a part of daily life as breathing air and drinking water. Electricity powers our lights, alarm clocks, coffee pots,

toasters, heating, ventilation and air conditioning, MP3 players, computers, televisions, traffic lights, subway systems, air traffic control networks, industry, and almost every other facet of daily life in the 21st century, and it's been that way for almost 100 years. The US National Academy of Engineering ranks "Electrification" as the #1 Engineering Achievement of the 20th Century.[1]

Much of American society is centered on individual mobility, extensive road networks, and large parking lots. The United States has more cars than registered drivers, and with a few notable exceptions, fuel has remained affordable and plentiful. Fuel costs moved from the subconscious to the conscious after recent increases in the price of oil and subsequent gasoline prices reaching $3 per gallon, but for the most part, increased fuel prices have done nothing to reduce consumption.

The United States imports 26% of its total energy supply and 56% of the oil it consumes.[2] The Department of Defense is the single largest consumer of energy in the United States[3]. The United States has built the mightiest military in world history, but has done so with little regard to the huge burden that comes with an insatiable appetite for energy.

DOD energy issues cannot be viewed in isolation. They are a subset of the larger national problem. Reducing dependence on imported energy is a critical national issue that must be addressed without delay.

First, the DOD needs to recognize the problem from a military perspective: energy is the key enabler of US military combat power. With that comes huge consumption of mostly imported petroleum based fuels, a command, control, communications, computers, intelligence, surveillance and reconnaissance (C4ISR) structure dependent on civilian electrical grid, rising

costs to support the military's energy needs, and no comprehensive strategy for energy or organizational structure to implement an energy strategy.

Second, the DOD must recognize that energy security makes the military vulnerable in several ways. DOD operations require assured access to large amounts of fuel for combat platforms and electricity for DOD installations from a fragile and vulnerable electrical grid. Recent cost increases and higher projected costs take defense dollars away from other key budget areas. Energy requirements are directly related to combat effectiveness, and the infrastructure required to transport and distribute energy to the battlefield is extremely expensive and diverts resources away from combat. Combat forces are limited by a "tether of fuel" that needs to be lengthened.

Third, the DOD has long operated under the assumption that energy is cheap and plentiful and energy has not been managed like other combat enablers, such as intelligence, acquisition, and logistics. This must end. Present DOD fuel costs represent only a 2.5 – 3% fraction of the national defense budget. That may seem small, but in a fiscally constrained wartime environment where DOD and Service budgets have already been cut, and cut again – every dollar is already committed. The forecast is for more of the same. An already huge national debt, federal budget deficits, and a looming fiscal storm of rising national health care costs and a potential Social Security crisis make fiscally constrained times appear permanent for the US Government.

Fourth, the DOD must have a long-term Energy Strategy and "energy chain of command", based on a comprehensive National Energy Strategy and a long-term vision of energy security 50 years from now and beyond. Ideally, America will reach a clean, carbon-neutral, domestically controlled, abundant, and affordable energy solution. No one really knows what the technology

or energy source will provide the fork in the road away from a largely petroleum dependent economy and military.

The DOD's Energy Strategy must also look at what can be done today and for the next 20-years to use energy more efficiently, use less energy, use more environmentally friendly forms of energy, diversify energy sources, increase physical security, and assure access to needed energy. This near-term strategy will buy time for research and technology to help America reach the long-term vision. This paper will focus on the more near-term, or the next 20-years.

In simple terms, DOD energy use can be divided into two main categories: petroleum based fuel for mobility platforms fuel, and infrastructure energy (electricity, natural gas, etc.) supporting installations and facilities. The vast majority of DOD energy consumption, some 74% of total energy cost, supports mobility platforms – aircraft, ships, and ground vehicles. Aviation fuel alone accounts for 58% of total DOD energy cost. Buildings/facilities account for 22% of DOD energy cost.[4] It makes perfect sense that if the DOD were to save energy that mobility platforms (particularly aircraft) and buildings are the likely place to begin.

This paper will primarily focus in those two energy categories. Although modern technology has created a growing demand to power electrical devices carried by the individual war fighter, this paper will not address those demands.

Chapter 2 will specifically discuss the energy problems of already high and growing demand, the true cost of fuel in dollars, force structure and combat capability, limited supply and increased competition for limited energy resources, and the DOD's current (or lack thereof) Energy Strategy.

Chapter 3 will look at the implications of DOD energy problems. These include vulnerabilities in fuel and electricity supplies, as well as Foreign Policy and economic vulnerabilities.

Chapter 4 will address the ongoing and needed actions required for the DOD to improve energy security through creation of an Energy Strategy and associated organization to implement the strategy through reduced demand, increased supply, diversification of energy sources, improved physical security, and more efficient and environmentally responsible energy use.

Finally, Chapter 5 will review the main points of the paper in perspective and provide concluding remarks.

---

[1] National Academy of Engineering, *Greatest Engineering Achievements of the 20th Century*

[2] Fournier, *Energy Trends and Their Implications. iv*

[3] House. *Hearings before the Subcommittee on Terrorism*, 4.

[4] Ibid.

Chapter 2 – Our Energy Problems

Demand

It is difficult to appreciate the scale in which energy is consumed on planet Earth. Current world consumption of oil averages 82.5 million barrels per day, which would fill a swimming pool measuring approximately 1-mile long by 1-mile wide and 17 feet deep, or 5,347 olympic sized swimming pools.[1] The United States consumes roughly 25% of that, or 20.7 million barrels per day,[2] with the government consuming roughly 1.9%, and the DOD accounting for 93% of government use.[3]

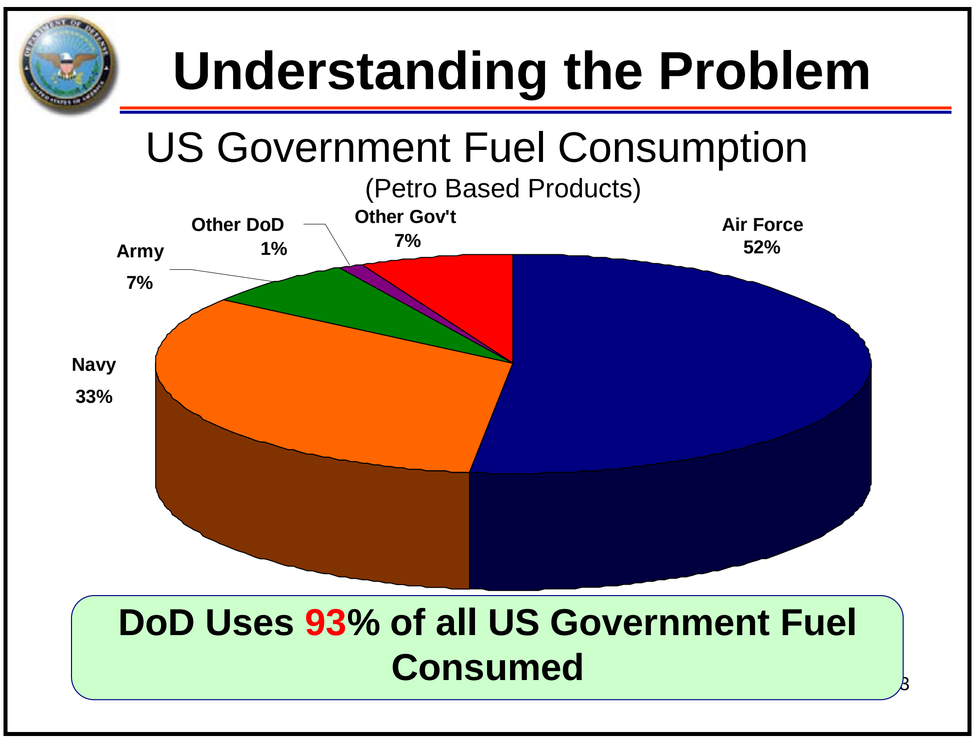


Figure 1 US Government Fuel Consumption. ***Reprinted from Mr. Chris DiPetto, Energy Efficiency for Tactical Systems, PowerPoint Presentation to 2006 PEO/SYSCOM Commanders' Conference.***

As the single largest consumer of energy in the United States, the DOD uses 4.6 billion gallons of fuel annually, or an average of 12.6 million gallons of fuel per day.[4] An Army heavy division may use 20 to 40 times the daily tons of fuel as it does ammunition, or about 600,000 gallons per day.[5] According to the *2005 CIA World Fact Book*, the DOD would rank 34th in the world as a country in average daily oil use, coming in just behind Iraq and just ahead of Sweden.

In FY 2006, the DOD used almost 30,000,000 Mega Watt Hours (MWH) of electricity, at a cost of almost $2.2 billion[6], with almost 100% of electricity supplied to DOD installations from the civilian market, or electric grid. As a point of reference, the total electricity consumption in the states of South Dakota and Idaho combined, used about the same amount, 30,764,000 MWHs[7], and would supply enough electricity to power 2,665,245 average American homes.[8] In electricity consumption, the DOD would rank 58th in the world as a country using slightly less than Denmark and slightly more than Syria.[9]

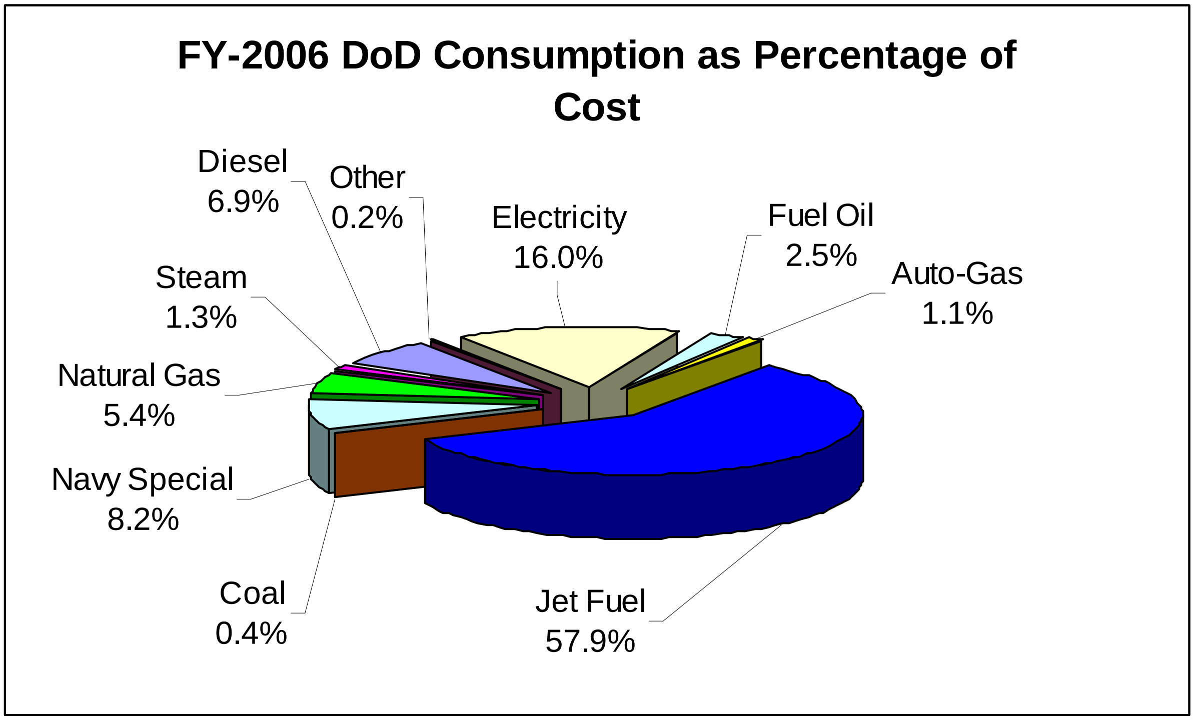


Figure 2 FY-2006 DOD Consumption as Percentage of Cost. ***Data from DOD FY 2006 Energy Management Data Report. Graph produced by author.***

The True Cost of Fuel

This fuel does not come cheap. The DOD spent approximately $13.55 billion on energy as a commodity in FY 2006. Of that, DOD spent roughly $10 billion on mobility fuels and $3.5 billion on facilities and infrastructure. A $10 per barrel increase in the cost of fuel increases DOD operating costs by roughly $1.3 billion per year,[10] which roughly equates to the entire 2007 procurement budget for the United States Marine Corps.[11]

Those numbers alone are staggering, and as illustrated in Figure 3 below, are clearly trending upward. The DOD bill for jet fuel in FY 2006 was $7.9 billion. This represents a 73% increase from the FY 2000 cost of $2.2 billion, with only a 12% increase in gallons consumed (largely attributable to the Global War on Terror). However, fuel costs for budgeting and resource planning have traditionally been based on the Defense Energy Support Center (DESC)

standard price, which does not reflect the cost of the fuel logistics system required to deliver fuel to the war fighter. The standard price of fuel represents only a fraction of the true cost.

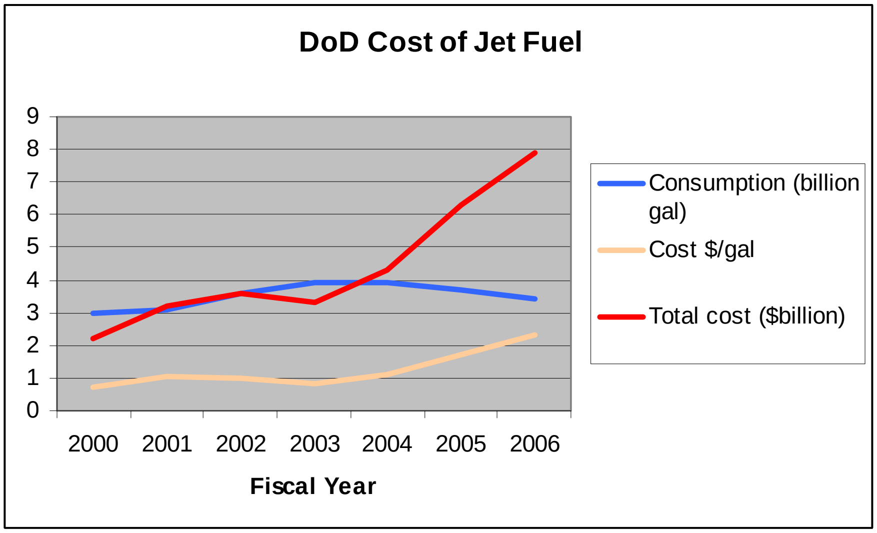


Figure 3 DOD Cost of Jet Fuel. ***Data from DOD FY 2000-2006 Energy Management Data Reports. Graph produced by author.***

A 2001 Defense Science Board study, *More Capable Warfighting Through Reduced Fuel Burden*, found the Air Force spent $4.4 billion to fuel aircraft over a 12-month period, $1.8 to purchase the fuel and $2.6 billion to deliver it via ground or air refueling. Only 6% of the total fuel purchased was delivered by air refueling, yet air refueling accounted for 85% of the delivery costs.[12] OSD recently conducted a more in-depth study on the *Burdened Cost of Fuel*, trying to capture the cost perspective to include the capital expenditure involved in building, operating and maintaining the fuel logistics infrastructure required to deliver fuel. The study began with the DESC standard fuel prices for the most commonly used DOD tactical fuels, and added costs of delivery asset operations and support, asset depreciation, infrastructure operations and support, and other service/delivery specific costs. The importance of the study lies more in the accounting methodology being developed than the actual numbers it produced, but the numbers are revealing nonetheless.

Amazingly, jet fuel purchased at $2.30 per gal costs the Air Force over $42 per gallon when delivered via air-refueling and costs $2.79 per gallon for ground delivery. This averages out to $6.36 per gallon total. Army and Navy average burdened fuel costs came out to $5.62 and $3.08 per gallon respectively.[13]

A long-range Army helicopter resupply mission, traveling 600km, with eight logistical supply aircraft providing fuel at three separate staging areas enroute would result in fuel costs approaching $400 per gallon as delivered to the resupply aircraft when accounting for the cost of aircraft utilization and fuel used to establish the staging areas.[14]

Force structure dedicated to fuel delivery is also very expensive. The Army alone has approximately 20,000 active and 40,000 reserve soldiers in fuel related jobs that cost around $3.2 billion per year.[15]

Lastly, dependence on fuel carries a high cost in combat capability which is impossible to quantify in dollars. In the early stages of Operation Iraqi Freedom (OIF), USAF MH-53M "Pave Low" special operations helicopters originally planned to base in Southern Turkey were forced, after Turkey denied US basing rights, to leap-frog from Cyprus in the eastern Mediterranean Sea across Turkey to an airstrip in Northern Iraq. The MH-53s were tasked to support Army Special Forces (SF) flown in via MC-130s from Romania, and to stand alert for Combat Search and Rescue (CSAR) until dedicated CSAR assets would arrive weeks later. The helicopters air refueled before entering Iraq to "top off" their fuel tanks. For several days during the most intense fighting of OIF, the fuel in their tanks was the only fuel available to conduct missions until the nightly MC-130P "Combat Shadow" passed overhead to conduct an air refueling resupply allowing the Pave Lows to "top off" for the next 24-hour period. An Army special operations support battalion impressively established fuel logistics support in only a few days,

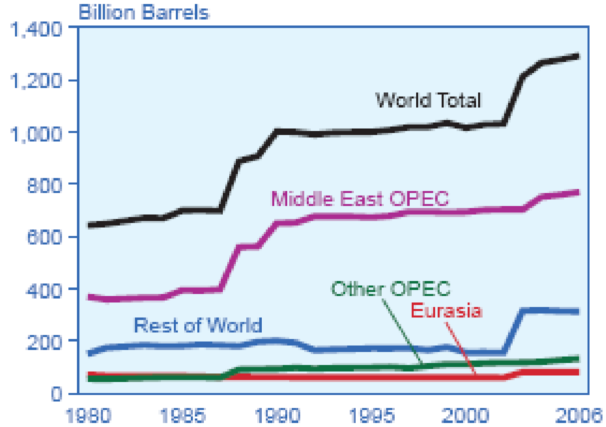
and the MC-130P tankers eventually co-located with the helicopters, but fuel was clearly the operational limitation early on.[16]

Ground units in OIF faced similar problems, as fuel represents over 50% of the DOD logistics tonnage and over 70% of the tonnage required to put the US Army into position for battle.[17] The pace of advance for some Army and Marine field units was so rapid that in order to maintain both the velocity and operational tempo of their highly mobile forces located across a wide battle space the subject of fuel was an ever present consideration. Lieutenant General James Mattis, Commanding General of the First Marine Division during OIF, issued a post-combat experience challenge to the Department of the Navy research officials to "Unleash us from the tether of fuel."[18]

Supply

This problem of high cost seems likely to only worsen. Proven reserves of oil are generally taken to be those quantities that geological and engineering information indicates with reasonable certainty can be recovered in the future from known reservoirs under existing economic and geological conditions. The historical trend for estimates of proven world oil reserves has generally trended upward, with new discoveries outpacing consumption (see figure 4). According to *Oil & Gas Journal*, world proven oil reserves, as of January 2006, were estimated at 1,293 billion barrels – 15 billion barrels higher than estimate for 2005.[19]

Figure 28. World Crude Oil Reserves, 1980-2006



Note: Reserves include crude oil (including lease condensates) and natural gas plant liquids.

Sources: 1980-1993: "Worldwide Oil and Gas at a Glance," *International Petroleum Encyclopedia* (Tulsa, OK: PennWell Publishing, various issues). 1994-2006: *Oil & Gas Journal* (various issues).

Figure 4 World Crude Oil Reserves, 1980-2006. ***Reprinted from DOE/EIA, International Energy Outlook 2006, 27.***

Table 3. World Oil Reserves by Country as of January 1, 2006
(Billion Barrels)

Country	Oil Reserves
Saudi Arabia	264.3
Canada	178.8
Iran	132.5
Iraq	115.0
Kuwait	101.5
UAE	97.8
Venezuela	79.7
Russia	60.0
Libya	39.1
Nigeria	35.9
United States	21.4
China	18.3
Qatar	15.2
Mexico	12.9
Algeria	11.4
Brazil	11.2
Kazakhstan	9.0
Norway	7.7
Azerbaijan	7.0
India	5.8
Rest of World	68.1
World Total	**1,292.5**

Source: "Worldwide Look at Reserves and Production," *Oil & Gas Journal*, Vol. 103, No. 47 (December 19, 2005), pp. 24-25.

Figure 5 World Oil Reserves by Country as of January 1, 2006. ***Reprinted from DOE/EIA, International Energy Outlook 2006, 28.***

How long will 1,293 billion barrels of oil last? There are so many variables that any period of time given is largely speculative. No one knows the scale of potential new oil discoveries, changes in consumption, or breakthroughs in technology that may occur. According to the Society of Petroleum Engineers, estimated proved reserves will supply the world with oil for approximately 44 years *at current consumption rates*.[20] However, the Department of Energy, Energy Information Administration (DOE/EIA), *International Energy Outlook 2006,* estimates world oil demand will increase from 80 million barrels per day in 2003 to 98 million barrels per day in 2015 and 118 million barrels per day in 2030. That's a 47% increase from 2003 to 2030. Much of the projected increase on oil consumption is attributed to strong economic growth in China and India.[21]

Global oil reserves are the source for the world oil market, but world oil *production capacity* is the current limiting factor affecting supply in the global market. Excess production capacity represents the ability to surge production to make up for increased demand or reduced production elsewhere in the market. Demand at or near supply with limited excess capacity characterizes a "tight" market. In the world oil market of today, excess capacity means political and economic clout.

The Persian Gulf contains 715 billion barrels of proven oil reserves, representing over half (57%) of the world's oil reserves. Also, at the end of 2003, Persian Gulf countries maintained about 22.9 million barrels per day of oil production capacity, or 32% of the world total. Perhaps even more significantly, the Persian Gulf countries normally maintain almost all of the world's excess oil production capacity. As of early September 2004, excess world oil production capacity was only about 0.5-1.0 million barrels per day, all located in Saudi Arabia.[22]

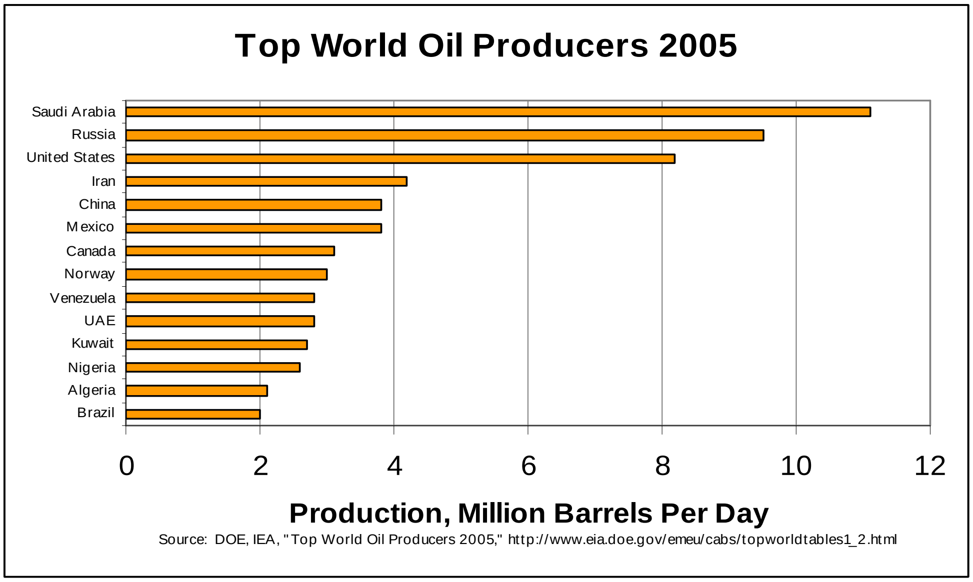


Figure 6 Top World Oil Producers 2005. ***Data from DOE/IEA, "Top World Oil Producers," graph produced by author.***

The DOD's Current Energy Strategy

Despite these trends there is no existing formal Department of Defense Energy Strategy and no single individual or organization responsible for energy issues within the Department. The DOD *Annual Energy Management Report* for FY 2006 lists the Principal Deputy Under Secretary of Defense (Acquisition, Technology and Logistics) as the DOD Senior Energy Official responsible for meeting the goals of Energy Policy Act of 2005 (EPAct 2005) and Executive Order (EO) 13123, *Greening the Government through Efficient Energy Management.*[23] However, this position has been vacant for several years and does not satisfy the need for a comprehensive Senior Energy Official for the Department.

This is not to say the DOD is unconcerned with energy issues. The Office of the Secretary of Defense (OSD) and the Services have recently conducted or sponsored numerous studies focusing on energy, many of which have been invaluable information sources for this paper: MITRE Corporation JASON Project, *Reducing DOD Fossil Fuel Dependence (2006);* Defense Science Board, *More Capable Warfighting Through Reduced Fuel Burden* (2001), and soon to

be released *Energy Strategy* (2006-2007); OSD Energy Security Integrated Product Team (2006); Air Force Scientific Advisory Board, *Technology Options for Improved Air Vehicle Fuel Efficiency* (2006); Navy Research Advisory Council, *Study on Future Fuels* (2005); Army Corps of Engineers, *Energy Trends and Their Implications for US Army Installations* (2005); and Defense Advanced Research Projects, *Petroleum-Free Military Workshop* (2005), to name a few. Common recommendations include making fuel efficiency a more significant factor in determining new mobility platforms (e.g. miles per gallon for ground vehicles, nautical miles/pound (lb.) fuel/lb. payload for aircraft and ships) and creating incentives for energy efficiency throughout the DOD. Additionally, none of the studies offered anything other than liquid hydrocarbons as the best fuel for DOD mobility platforms for at least the next 25 years.

Impressive groups of energy experts have produced many of these studies, but they are all either Service specific or temporary in nature, meaning the group of experts dispersed after writing the study's final report. The lack of a full-time energy advocate within the DOD leaves a void in follow-up actions to study recommendations, or creation of directive guidance on energy issues within the Department.

The good news is most of the energy expertise already exists in various functional areas of OSD and the Services, and parts of a comprehensive Energy Strategy are already in place. The Air Force recently published an Energy Strategy, focused on optimizing energy use, reducing demand, and expanding supply options. These issues will be targeted primarily through initiatives in aviation, and infrastructure and vehicles.[24]

The DOD already has an outstanding installations and facility energy management program led by the Deputy Under Secretary of Defense for Installations and Environment that in many ways is a model for the federal government.

Facility Energy Management Policy Statement:

> The Department of Defense (DOD) occupies over 620,000 buildings and structures worth $600 billion comprising more than 400 installations on 25 million acres in the United States and spent over $3.5 billion on facility energy consumption in Fiscal Year (FY) 2006. DOD is the largest single energy consumer in the Nation representing approximately 78% of the federal sector, and a significant (and sometimes the largest) energy user in many local metropolitan areas. Conserving energy and investing in energy reduction measures makes good business sense and allows limited resources to be applied to readiness and modernization. The Department has already reduced its facility energy consumption significantly; by FY 2005 the Department had already achieved a reduction in energy consumption by 28.3 percent as compared to a FY 1985 baseline. Due to the Energy Policy Act of 2005 in FY 2006 the baseline was reset to FY 2003. DOD achieved a 5.5% reduction in goal facilities for FY 2006. Despite this success, the Department must make greater strides in energy efficiency and consumption reduction in order to meet the Departmental vision of providing reliable and cost effective utility services to the Warfighter. Dramatic fluctuations in the cost of energy significantly impact already constrained operating budgets, providing even greater incentives to conserve and seek ways to lower energy consumption. These include investments in cost-effective renewable energy sources, energy efficient construction designs, and aggregating bargaining power among regions and Services to get better energy deals.[25]

In November 2005, the Deputy Under Secretary of Defense (Installations and Environment), Mr. Phil Grone, published a memo to the Services and Directors of Defense Agencies to provide facility energy management goals consistent with current legislation, Executive Orders, and DOD direction.

"The Department of Defense will strive to modernize infrastructure, increase utility and energy conservation and demand reduction, and improve energy flexibility, thereby saving taxpayer dollars and reducing emissions that contribute to air pollution and global climate change."[26]

Applicable goals from Mr. Grone's memo to the Services:

- Greenhouse Gases (GHG) Reduction: Through life-cycle cost-effective measures, each Defense component shall reduce its greenhouse gas emissions attributed to facility energy use by 30% by 2010 (compared to 1990 levels).

[Note: Kyoto Protocol GHG reduction goals for the United States was 7%]

- Reduce Energy: Through life-cycle cost-effective measures, each Defense component shall reduce energy consumption per gross square foot of its facilities.
    - All facilities: Reduce consumption by 2 percent/year relative to 2003 baseline.
    - Facility Energy Audits: Conduct energy and water audits at 10% of facilities each year.
- Renewable Energy Procurement: Each Defense component shall strive to expand the use of renewable energy within its facilities and in its activities by implementing renewable energy projects and by purchasing electricity from renewable sources. Renewable Goals (when life-cycle cost-effective):
    - 3% of their total electricity demand in FY 2007-2009
    - 5% in FY 2010-2012
    - 7.5% in 2013
    - 25% by 2025
- Petroleum Use: Through life-cycle cost-effective measures, each Defense Component shall reduce the use of petroleum within its facilities. Components may accomplish this reduction by switching to a less GHG-intensive, non-petroleum energy source, such a natural gas or renewable energy sources; by eliminating unnecessary fuel use; or by other appropriate methods.

The $3.5 billion the DOD spent on facilities and infrastructure energy does have an oversight structure in place. By contrast, the $10 billion spent on fuel, countless billions spent on force structure, fuel logistics and research and acquisition does not have an oversight structure in place. This must be corrected with a comprehensive strategy, oversight, and energy advocate in the department.

---

[1] Calculation by author. 82.5M bbl x 42 gal/bbl = 3.465B gal x 0.133680556ft^3/gal = 463,203,127 ft^3 = 5,280ft x 5,280ft x 16.6ft.

[2] Energy Information Administration, *International Energy Annual 2004,* Table 12.

[3] MITRE Corporation, *Reducing DOD Fossil Fuel Dependence*, 14.

[4] Department of Defense, *FY 2006 Energy Management Data Report.*

[5] MITRE Corporation, *Reducing DOD Fossil Fuel Dependence,* 13.

[6] Department of Defense, *FY 2006 Energy Management Data Report*, table 1-1, 1-2.

[7] Energy Information Administration, *Electric Power Annual 2005,* 47.

[8] According to EIA (http://tonto.eia.doe.gov/ask/electricity_faqs.asp#electricity_use_home), the average US home uses 938KWH of electricity monthly (accessed 20 Mar 2007).

[9] NationMaster.com, http://www.nationmaster.com/graph/ene_ele_con-energy-electricity-consumption#source (as derived from CIA World Fact Book 2006).

[10] House. *Hearings before the Subcommittee on Terrorism,* 5.

[11] HR 5122, 109th Cong., 2nd sess., 2006, sec. 102 (b).

[12] Defense Science Board, *More Capable Warfighting Through,* 17.

[13] OSD(PA&E). *Burdened Cost of Fuel*.

[14] Defense Science Board, *More Capable Warfighting Through*, 19.

[15] Ibid., 39.

[16] Account by author, 21st Special Ops Sqdn commander (MH-53M) at the start of OIF.

[17] Defense Science Board, *More Capable Warfighting Through*, 4

[18] Office of the Assistant Secretary of the Navy (Research, Development and Acquisition), *Future Fuels*, 3. Emphasis added.

[19] Energy Information Administration, *International Energy Outlook 2006*, 27.

[20] Society of Petroleum Engineers, *How Much Oil and Natural*, Emphasis added by author.

[21] Energy Information Administration, *International Energy Outlook 2006*, 25.

[22] Energy Information Administration, Country Analysis Briefs, *Persian Gulf Oil and Gas Exports Fact Sheet*, http://www.eia.doe.gov/emeu/cabs/pgulf.html (accessed 20 February 2007).

[23] Superseded by EO 13423, *Strengthening Federal Environmental, Energy, and Transportation Management*, 26 January 2007.

[24] Wynne, USAF Energy Forum.

[25] DUSD (I&E) Facility Energy Management Policy Statement, www.acq.osd.mil/ie/irm/ Energy/Energy%20Home/EnergyAboutPolicyStatement.htm (accessed 21 February 2007).

[26] Grone to Service Secretaries, memorandum.

Chapter 3 – Implications of the Problem- Vulnerability

> ***Vulnerability:*** *The susceptibility of a nation or military force to any action by any means through which its war potential or combat effectiveness may be reduced or its will to fight diminished.*
>
> ***Strategic vulnerability:*** *The susceptibility of vital instruments of national power to being seriously decreased or adversely changed by the application of actions within the capability of another nation [or non-state actor] to impose. Strategic vulnerability may pertain to political, geographic, economic, informational, scientific, sociological, or military factors.*
>
> Joint Publication 1-02
> DOD Dictionary of Military and Associated Terms

US dependence on huge amounts of oil and electricity to power our economy and our military creates much vulnerability. It would not be wise to publish a detailed list of vulnerabilities of US and global energy critical infrastructure and key resources; however, it is no big secret that vulnerabilities exist. Terrorists or common vandals in either the United States or around the globe have already attempted all of the open source referenced scenarios described in this chapter.

Potential Oil Supply Disruptions

"Our nation's dependence on imported oil leaves it dangerously vulnerable to attack. A single well-designed attack on the petroleum infrastructure in the Middle East could send oil to well over $100 per barrel and devastate the world's economy."[1]

A recent Congressional Research Service report to Congress highlighted terrorists emphasis on exploiting oil vulnerabilities:

> Al Qaeda leaders' statements reveal sophisticated consideration of the economic and military vulnerabilities of the United States and its allies, particularly with regard to the role of Middle Eastern oil as "the basis of industry" in the global

> economy. Statements by Bin Laden and Al Zawahiri urging attacks on oil infrastructure and military supply lines could indicate a shift in Al Qaeda's strategic and tactical planning in favor of a more protracted attritional conflict characterized by disruptive attacks on economic and critical energy production infrastructure. For example, in an interview reportedly conducted on or around the fourth anniversary of the September 11 terrorist attacks, Al Zawahiri urged "mujahidin to concentrate their campaigns on the Muslims' stolen oil" and to "not allow the thieves ruling [Muslim] countries to control this oil." Bin Laden has called for Muslim societies to become more self-sufficient economically and has urged Arab governments to preserve oil as "a great and important economic power for the coming Islamic state." Bin Laden also has described economic boycotts as "extremely effective" weapons.[2]

Instability and hostility towards the United States characterizes most of the oil-producing world. An oil supply crisis can no longer be dismissed as a low-probability event. Hostile governments and terrorist organizations are well aware of America's and her allies' vulnerability and could use oil supply as a strategic weapon to attack the United States. Oil supply disruptions to the United States could happen in several ways, occurring either singularly or combined. These include disruptions in world production by natural disaster, politically motivated embargo, terrorist attack on production and transmission infrastructure, or closure of world oil transit chokepoints. Any long-term disruption in oil supply to the United States is a National Security issue unacceptable to the US government. However, most of these scenarios assume a major world-wide upheaval or political and other major changes in the primary oil production regions of the world and go beyond the scope of this paper.

Additionally, in the event of a catastrophic shut down of world oil flow, our government will ensure the DOD has priority access to domestic oil production and the 700-1000 million barrels of oil in the Strategic Petroleum Reserve. However, scenarios of supply disruptions to DOD installations via the US oil and gas transmission pipeline system or to deployed operational forces via fuel logistics distribution networks are not completely far fetched.

Almost a half million miles of oil and gas transmission pipeline serve the United States. These pipelines are integral to US energy supply and have vital links to other critical infrastructure, such as power plants, airports, and military installations. The pipeline networks are widespread, running through remote and densely populated regions and are vulnerable to accidents and terrorist attack. Roughly 160,000 miles of pipeline carry over 75% of the nation's crude oil and around 60% of its refined petroleum products. The US natural gas pipeline network consists of around 210,000 miles of pipeline for field gathering and transmission nation wide.[3]

Pipelines are vulnerable to vandalism and terrorist attack with firearms, explosives, or other physical means. Some may also be vulnerable to "cyber-attack" on computer control systems or be vulnerable to an attack on the electric grid supplying power to them. Oil and gas pipelines have been targeted extensively by terrorists outside and within the United States. Rebels have targeted one oil pipeline in Colombia over 600 times since 1995. In 1996, London police foiled a plot by the Irish Republican Army to bomb gas pipelines and other utilities. Since 9/11, federal warnings about Al Qaeda have specifically mentioned pipelines as possible targets. The 800 mile long Trans Alaska Pipeline System (TAPS), which runs from Alaska's North Slope oil fields to the marine terminal in Valdez, Alaska, delivers nearly 17% of US domestic oil production. TAPS has already been targeted numerous times, and in January 2006, federal authorities acknowledged a detailed posting on a website purportedly linked to Al Qaeda that encouraged attacks on US pipelines, especially TAPS, using weapons or explosives.[4]

Deployed operational forces are particularly vulnerable to supply disruptions. Fuel is delivered by convoy to Iraq from Jordan, Kuwait, and Turkey. In FY 2006, over 156 million gallons of fuel were delivered to US/coalition forces in western Iraq. In the north, over 103

million gallons of fuel were delivered through Turkey utilizing 17,802 trucks which, if put end to end, would stretch from Washington D.C. to Wilmington, Delaware.[5] In July 2006, USMC Major General Richard Zilmer, commander of the multi-national force in western Iraq, submitted a priority request for a self-sustainable energy solution to reduce the number of fuel logistics convoys in Iraq that are increasingly vulnerable to attack.[6]

Figure 7 Fuel Convoy Traveling North into Iraq. ***Photo reprinted from Marine Corps Air Ground Combat Center website*.**

Potential Electricity Supply Disruptions

Electricity 101

The DOD is just as dependent on electricity as the average American consumer. Electricity powers our command, control, communications, computers, intelligence, surveillance, and reconnaissance networks, hospitals, lighting, heating and air conditioning, and thousands of other electronic devices. This great capability has also created a significant vulnerability. Without

electricity we'd go back to sending information with flags and bugle calls. To be sure, critical command and control nodes and other key facilities such as hospitals are backed-up by uninterrupted power supplies, or diesel generators designed to supplement for short-term power interruptions, but what about the rest of the installation? How prepared is the department for a long-term power outage of 6-months or a year?

An understanding of some basic elements of our electric power distribution system is essential to see how vulnerable military installations are to electrical power disruption.

In simple terms, the US electric grid is a network of networks, like a spider's web between power plants and consumers of electricity all over North America. The web has many parts, and components required for delivery vary for different consumers, but a typical electricity delivery scenario is described below.

First, power plants must generate electricity by converting primary sources of energy, such as coal, natural gas, geothermal, or nuclear energy to electricity. An electric utility power station uses a turbine, engine, or other machine to drive an electric generator that coverts mechanical energy to electricity. These generation plants are becoming increasingly automated and controlled by supervisory control and data acquisition, or SCADA, systems that can be accessed through the Internet or by phone lines in order to increase efficiency through remote operations.[7]

In most cases, electricity flows from the generating facility to a step-up transmission substation where the electricity passes through a transformer to increase the voltage. Higher voltage allows the electricity to travel efficiently and quickly through high-voltage transmission lines. High-voltage transmission lines deliver the electricity to a step-down transmission substation, where the electricity passes through another transformer to reduce the voltage for delivery to distribution substations.

Distribution substations are located closer to the electricity consumers, and usually reduce the transmission voltage once again for use by end-users. Electricity is then distributed via lower-voltage distribution lines, and may pass through several other transformers before the electricity is actually used by consumers. These transformers are usually visible to consumers as the grey trash-barrel-sized cylinders on utility poles.

The network of networks comprising the US electric grid is enormous, and often referred to as "the world's biggest machine." More than 5,300 traditional electric utilities and non-utility power producers, operating more than 16,800 generators net produced 4,054,688,000 KWH of electricity for roughly 138,000,000 million customers in the United States in 2005.[8]

In the Unites States, there are over 10,000 transmission substations and over 2,000 distribution substations. Substations are a critical component of the electric grid. A loss of only 4% of transmission substations would result in a 60% loss of connectivity.[9]

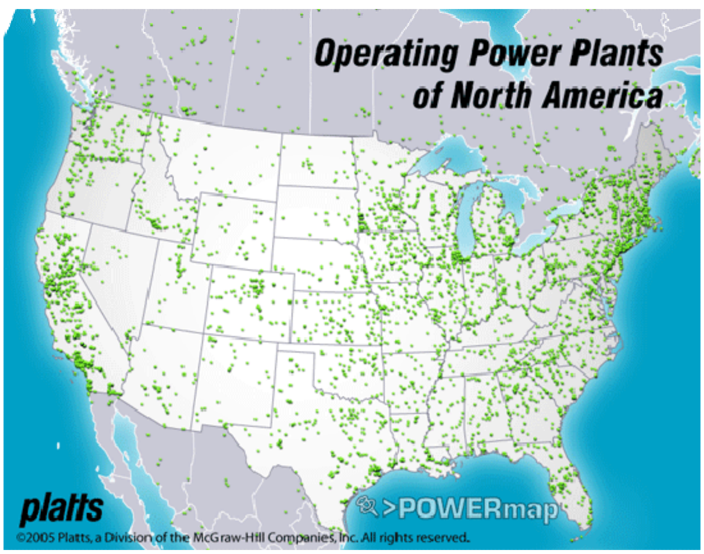


Figure 8 Operating Power Plants of North America. ***Image reprinted from Platts, a division of McGraw-Hill Publishing.***

Sabotage, Physical, and Cyber Attack

> The vulnerability of oil and gas terminals, processing plants, and pipelines is mirrored in central electric systems – only worse. The General Accounting Office

> recently audited the electrical security of a typical part of the United States; the audit found that sabotage of eight substations could black out the region, and that sabotage of only four could leave a city with no power for days and with rotating blackouts for a year.
>
> The roots of this vulnerability are not hard to find. To start with, electricity, though not itself flammable or explosive, cannot be readily stored. The electric grid provides no "pipeline inventory" of storage between generators and end users (unless they have provided local storage or back-up at their own expense). Thus, in the event of supply or delivery failures, electric power must be rapidly rerouted to prevent widespread and instantaneous failure. This rerouting requires that generating and transmission capacity, switchgear, and control and communications capability be immediately available. [10]

Each of the major components of the power grid discussed in the previous section; power generation facilities; transmission substations; transmission lines; and distribution substations represent a physical vulnerability.

Of particular concern is the long lead times for replacing many of critical components required to make the system work. For example, high voltage transformers are generally reliable, expensive, and often built overseas for specific installations; therefore few spares are kept on hand. They can take from weeks to a year to replace.[11]

This vulnerability has the attention of Congress. As part of the Energy Policy Act of 2005, Congress tasked DOE to conduct a study and provide a report to the President and Congress on the benefits of using mobile transformers and mobile substations to restore power in the event a blackout caused by natural disaster, equipment failure, acts of terrorism or war. The passage below is from that study and highlights the short coming in high voltage transformers:

> Intentional disruptions such as sabotage could severely harm our Nation's electrical grid, and most substations are very vulnerable to attack. Substations are usually unmanned, remote, exposed, and have few physical barriers. Utilities rely more on redundancy of the grid for mitigation rather than on hardening of individual sites. The larger sites frequently have personnel and improved protections, but the consequences of loss of these large sites are comparatively greater as well. There are few options available for the replacement of a destroyed high-power transformer. While Mobile Transformer and Substation (MTS) Systems as large as 100 MVA exist, MTS systems are typically below 50 MVA in

size, with high-side voltages not exceeding 230 kV. High-power transformers, as described above, are greater than 100 MVA and can have high-side voltages of 345 kV or higher and at present can not be backed up by MTS.[12]

Computer and remote control of power generation and transmission adds both efficiency and vulnerability. "Hundreds of times a day, hackers try to slip past cyber-security into the network of Constellation Energy Group Inc., a Baltimore power company with customers around the country."[13]

Thus far, the hackers have caused no serious damage to the power grid, but their efforts have heightened concerns the system is vulnerable and that companies have failed to adequately fortify against cyber attack. "The fear: In a worst-case scenario, terrorists or others could engineer an attack that sets off a widespread blackout and damages power plants, prolonging an outage."[14]

The Department of Energy's Idaho National Laboratory (INL) simulations show how a skilled hacker could cause serious problems by infiltrating a utility company's Internet-based business management system to control utility operations. Once inside the company's network, the INL workers simulated cutting off the oil supply to a turbine generating electricity, which would have destroyed the equipment and shut down the plant.[15]

In describing his reaction to the demonstration, Patrick H. Wood III, the chairman of the Federal Energy Regulatory Commission, said: "I wished I'd had a diaper on."[16]

Infrastructure Failure

"The US power transmission system is in urgent need of modernization. Growth in electricity demand and investment in new power plants has not been matched by investment in transmission facilities. Maintenance expenditures have decreased 1% per year since 1992. Existing transmission facilities were not designed for the current level of demand, resulting in an

increased number of "bottlenecks," which increase costs to consumers and elevate the risk of blackouts."[17]

The American Society of Civil Engineers gave "Energy" or the "US Electric Power Grid" a "D" grade in its Infrastructure Report Card for 2005. The primary reason for alarm is inadequate investment in the transmission grid for an increasing national demand for electricity.

In August 2003, an electrical blackout hit the Midwest, Northeast and portions of Canada. A series of power plants and transmission lines went offline due to instability in the transmission system in three states. This led to greater instability in the regional power transmission system, and, within 4-hours, a rapid cascade of additional power plant and transmission line outages caused a large scale blackout. The blackout affected as many as 50 million customers in the United States and Canada, as well as a wide range of vital services and commerce, including air and ground transportation systems, shutdown of drinking water and sewage processing systems, and failure of some emergency communication systems.[18]

Foreign Policy Vulnerability

> The lack of sustained attention to energy issues is undercutting US foreign policy and US national security. Major energy suppliers – from Russia to Iran to Venezuela – have been increasingly able and willing to use their energy resources to pursue their strategic and political objectives. Major energy consumers – notably the United States, but other countries as well – are finding that their growing dependence on imported energy increases their strategic vulnerability and constrains security objectives.[19]

Foreign Policy issues are daily concerns for the White House and the Department of State, but the DOD is typically the department called upon when Foreign Policy goes awry. In his article, *Energy Security: The New Threats in Latin America and Africa,* David L. Goldwyn, a senior fellow at the Center for Strategic and International Studies, argues current US energy dependency challenges US power in five ways. First, many nations dependent on consuming

imported oil makes them reluctant to join coalitions led by the United States to combat weapons proliferation, terrorism or aggression. Examples are the French, Russian and Chinese resistance to sanctions on Iran; Chinese resistance to sanctions against Sudan; and US tolerance of Middle East repression that would otherwise been sanctioned were it to occur in any other non-oil-producing part of the world.[20]

Secondly, high oil revenues in the hands of oil exporting nations allow governments to act with impunity against their own people and work against the United States and their neighbors. Venezuelan President Hugo Chavez, Latin America's loudest anti-American cheerleader, has used oil revenue to build support for his economic vision by providing subsidized oil to products to neighboring countries and gain leverage over them by purchasing bonds to finance their debt. Russian President Vladimir Putin has renationalized his energy sector, restricted foreign access to his pipeline system, and demanded open access to Europe. Iran has reduced its international debt and increased foreign reserves to prepare of possible sanctions. "Even Saudi Arabia's economic reform movement, born in the days of $10 oil in 1998, evaporated when oil reached $30 per barrel in 2000. Enrichment of America's competitors or adversaries harms US security interests in every part of the globe".[21]

The third problem is the global oil market is far from being a fair free market system. Governments which do not allow free market access to develop, exploit and expand supplies control most of the world's major oil reserves. Most free market commodities allow the market supply to expand to meet demand. As oil prices rise, many governments are less receptive to foreign investment, preventing supply from responding to demand and driving prices even higher.[22] An increased price of imported goods increases the US trade deficit and exports wealth

to foreign lands. In 2005, imported oil accounted for one-third of the country's $800 billion trade deficit.[23]

A fourth problem created by the highly competitive world oil market is the political gamesmanship that undermines the fluidity and fairness of the market for available supplies. "New competitors like China and India are trying to negotiate long term contracts (at market prices) to ensure they have supplies in the event of a crisis or supply disruption…From an economic point of view it may not matter if China lends Angola $3 billion at low interest to gain part of an exploration project as long as the oil is produced. But China gains an enormous geopolitical advantage by this act."[24]

A fifth problem oil dependency creates for America and directly impacts the DOD is vulnerability to price volatility that result from supply and demand shocks.[25] From the fall of 2005 until gasoline prices started to decline in fall 2006, the "price of gasoline" had replaced "the weather" as every American's favorite subject of conversation with a stranger. The price of standard crude oil on NYMEX was under $25 per barrel in September 2003, but by August 11, 2005, increased to over $60 per barrel, and topped out at a record price of $78.40 per barrel on July 13, 2006.[26] Experts attributed the spike in prices to a variety of factors, including war in Iraq, North Korea's missile launches, the crisis between Israel and Lebanon, Iranian nuclear brinkmanship, and Hurricane Katrina. None of these factors, except for war in Iraq, could be controlled by the US government.

The global energy infrastructure built over the last century is quite fragile and was not designed with any vision of terrorist attacks or computer hackers. The DOD must accept the fact that vulnerabilities exist and that bad actors will eventually exploit these vulnerabilities if corrective measures are not taken.

[1] National Research Council, *Improving the Efficiency of Engines*, 89.
[2] Blanchard, *Al Qaeda: Statements and Evolving Ideology*, 12.
[3] Parfomak, *Pipeline Safety and Security*, 1-2.
[4] Ibid., 3.
[5] Defense Energy Support Center, *Fact Book FY 2006*, 88-89.
[6] Donnelly, "Military Wants a More," A1.
[7] Blum, "Hackers Target U.S. Power."
[8] Energy Information Administration, *Electric Power Annual 2005*, 3, 14, 45.
[9] Department of Energy, *The Electricity Delivery System*, 2.
[10] Lovins, *Brittle Power*, 123.
[11] Ibid., 131.
[12] Department of Energy, *Benefits of Using Mobile Transformers*, 11.
[13] Blum, "Hackers Target U.S. Power."
[14] Ibid.
[15] Ibid.
[16] Ibid.
[17] American Society of Civil Engineers (ASCE), *Infrastructure Report Card 2005.*
[18] Ibid.
[19] Deutch, *National Security Consequences of US*, 3.
[20] Goldwyn, "Energy Security: The New Threats," 441.
[21] Ibid.
[22] Ibid., 442.
[23] Senate. *Energy Diplomacy and Security*, 46.
[24] Goldwyn, "Energy Security: The New Threats," 442.
[25] Ibid.
[26] TFC Commodity charts, Light Crude Oil: http://futures.tradingcharts.com/chart/CO/M (accessed 20 February 2007).

Chapter 4 – Energy Strategy and Implementation for Improved Energy Security

> *Fans often have the image in their minds of a big hitter coming up with the bases loaded, two outs, and the home team three runs behind. The big hitter wins the game with a home run. We are addicted to home runs, but the outcome of a baseball game is usually determined by a combination of walks, stolen bases, errors, hit batsmen, and, yes, some doubles triples and home runs. There's also good pitching and solid fielding, so ball games are won by a wide array of events, each contributing to the result.*
>
> George P. Shultz
> Former Secretary of State

In the Foreword of Amory Lovins' book, *Winning the Oil Endgame*, former Secretary of State George P. Shultz uses a baseball analogy to describe how the US needs to rely on a steady, incremental approach to move forward on reducing the United States' addiction to foreign oil and securing the energy future. The solution for the Department of Defense is no different.

Energy Strategy

Although there are many intelligent energy experts residing within the Department of Defense and many outstanding efforts underway contributing to improve energy security, the DOD does not currently have a permanent organizational focal point or advocate for energy issues or a written long-term Energy Strategy. The DOD needs both - an organizational structure to serve as the focal point for energy issues and an Energy Strategy that:

- Improves National Security by decreasing US dependence on foreign oil
- Ensures access to critical energy requirements
- Maintains or improves combat capability
- Promotes Research for future energy security
- Is fiscally responsible to the American tax payer

- Protects the environment

Decreasing US dependence on foreign oil in a meaningful way can only be done by looking at the wide array of ways the DOD can consume less petroleum based fuel through efficiencies, smarter processes, and diversification of fuel sources to include alternatives other than petroleum.

Domestically controlled production of alternative fuels will also help assure access to critical energy requirements. Additionally, the DOD must ensure resiliency of installation electricity supply through increased on-site renewable energy production, reduced dependence on the commercial electric grid, and the capability to operate at 100% capacity in the event of a commercial grid blackout.

Improved combat capability will result from the efficiency effects and lengthening the "tether of fuel." Reduced logistics requirements energy costs will allow assets and funds to be diverted to combat needs and more responsibly spend hard earned taxpayers' dollars.

Lastly, reduced consumption and increased alternative and renewable energy production will help preserve the environment through reduced carbon emissions and more efficient use of natural resources.

Implementing Strategy

Organizational Change

There is a proud tradition in the United States Government that when issues arise a bureaucracy is created to deal with it. Larger problems are often treated with larger bureaucracies. Recent examples include the creation of the Department of Homeland Security and the Director of National Intelligence in response to the attacks of and intelligence failures associated with 9/11. Were there to be a national security incident involving DOD energy use,

for example, a prolonged electrical blackout impacting DOD installations, Congress would surely impose a very prescriptive organizational change in the department.

In order to prevent such an event and to initiate change on its own terms, the DOD must reshuffle its organizational portfolios to create a specific focal point, or energy advocate in the Office of the Secretary of Defense (OSD) to create and implement a department-wide Energy Strategy. Using Secretary Shultz' baseball analogy, the team currently has no manager. The goal, of course, is not to identify a vague need such as "the DOD needs an Energy Czar" and create additional bureaucracy in the negative sense with an excessive number of administrators, red tape, and petty energy officials, but instead to properly define the requirement and parse authority on energy issues to a specific individual with the authority to allocate resources and establish policy on energy security for the Department. Authority is a zero-sum-game. A new position with authority over energy issues cannot be established without taking authority from someone else.

United States Code, Title-10, provides guidance on the structure of the Office of the Secretary of Defense:

```
                    TITLE 10--ARMED FORCES

               Subtitle A--General Military Law

          PART I--ORGANIZATION AND GENERAL MILITARY POWERS

            CHAPTER 4--OFFICE OF THE SECRETARY OF DEFENSE

Sec. 131. Office of the Secretary of Defense

    (a) There is in the Department of Defense an Office of the Secretary
of Defense. The function of the Office is to assist the Secretary of
Defense in carrying out his duties and responsibilities and to carry out
such other duties as may be prescribed by law.
    (b) The Office of the Secretary of Defense is composed of the
following:
        (1) The Deputy Secretary of Defense.
        (2) The Under Secretaries of Defense, as follows:
            (A) The Under Secretary of Defense for Acquisition,
        Technology, and Logistics.
```

(B) The Under Secretary of Defense for Policy.
(C) The Under Secretary of Defense (Comptroller).
(D) The Under Secretary of Defense for Personnel and Readiness.
(E) The Under Secretary of Defense for Intelligence.

(3) The Director of Defense Research and Engineering.
(4) The Assistant Secretaries of Defense.
(5) The Director of Operational Test and Evaluation.
(6) The General Counsel of the Department of Defense.
(7) The Inspector General of the Department of Defense.
(8) Such other offices and officials as may be established by law or the Secretary of Defense may establish or designate in the Office.[1]

A logical level to establish an energy specific position would be at the Assistant Secretary of Defense (ASD) level. An ASD could either report to directly to the Secretary of Defense, as do the ASDs for Legislative and Public Affairs, or could be made subordinate to an Under Secretary of Defense (USD) like the ASD for Health Affairs (reports to USD Personnel & Readiness.)

The USD (AT&L) already possesses most of the key organizational structure and expertise to create and implement a DOD Energy Strategy, for example, the DUSD for Installations & Environment is responsible for energy management at DOD installations and the Director of Research & Engineering responsible for new technologies that could lead the DOD away from oil dependence. Energy issues cannot be separated from the various research, installations, acquisition programs, and logistics functional areas under AT&L, but there can be comprehensive energy oversight. Since many of the existing energy fiefdoms reside under DUSDs and agency directors in AT&L, it would make sense to establish an oversight position at the higher level of ASD. Title 10 specifically authorizes nine ASDs and gives congressionally mandated job descriptions for five of them (Reserve Affairs; Homeland Defense; Special Operations and Low Intensity Conflict; Legislative Affairs; Nuclear and Biological and Chemical Defense Programs.) Establishing an ASD for Energy Security beneath the USD

(AT&L) would have to be authorized by Title 10. Specific duties, not necessary to be prescribed in Title 10 unless the position is directed by Congress, could be described as follows:

> (a) There is an Assistant Secretary of Defense for Energy Security, appointed from civilian life by the President, by and with the advice and consent of the Senate.
> (b) The Assistant Secretary is the principal adviser to the Secretary and the Under Secretary of Defense for Acquisition, Technology, and Logistics on Energy Security and energy issues within the Department of Defense and is the principal energy official within the senior management of the Department of Defense.
> (c) The Assistant Secretary shall perform such duties relating to Energy Security as the Under Secretary of Defense for Acquisition, Technology, and Logistics may assign, including--
> (1) prescribing, by authority of the Secretary of Defense, policies and programs for the implementation of an Energy Strategy to enhance Department of Defense Energy Security and combat capability;
> (2) advising and assisting the Secretary of Defense, the Deputy Secretary of Defense, and the Under Secretary of Defense for Acquisition, Technology, and Logistics providing guidance to and consulting with the Secretaries of the military departments, with respect to Energy Security of the Department of Defense; and
> (3) monitoring and reviewing all energy programs in the Department of Defense.

The ASD for Energy Security must oversee a comprehensive study and direct actions by the Services to assure access to critical energy requirements. Vulnerabilities addressed in Chapter 3 must be identified and eliminated where possible, else mitigated. This includes petroleum and electricity infrastructure servicing military installations, improving renewable energy production and back-up generator capability in the event of a long-term civilian grid blackout.

Additionally, the DOD should set aside funding to be allocated at the discretion of the ASD for Energy Security for energy saving programs that do not compete well within the Service budget drills. Funding for energy saving programs exists to some extent for DOD facilities only, but must be expanded to include other energy saving programs. Another funding tool, the Energy Savings Performance Contract (ESPC), allows federal agencies to enter contracts for the purchase of facility energy saving measures, with an agreement between the contractor and the agency to use the funds saved by those measures to pay for the project. The ASD for Energy

Security should aggressively pursue legislation to expand ESPC to other DOD energy programs, such as the aircraft re-engining programs discussed later in this chapter. The Air Force would likely jump at the chance to execute these programs, but not at the expense of other programs such as the F-22. Supplemental funding or ESPC's for energy savings programs could be the catalyst for getting these programs over the budgetary hurdles.

Lastly, the ASD for Energy Security must leverage existing energy efforts and studies and ensure appropriate actions are taken. A great deal of work has already been accomplished in the previously mentioned studies, and the ASD for Energy Security should follow-up to ensure proper actions are taken. Creating the ASD for Energy Security is the baseball equivalent of filling a vacant manager's position.

The 2007 National Defense Authorization Act, Section 360, specifically tasks the Secretary of Defense to submit to Congress, not later than 16 October 2007, a report to include:

- An assessment of the feasibility of designating a Senior DOD official to be responsible for implementing the policy of improving fuel efficiency in weapons platforms
- A summary of recommendations from the reports of three recent DOD energy studies; the Energy Security Integrated Product Team (2006); The Defense Science Board Task Force on DOD Energy Strategy (2006); and The Defense Science Board Task Force on Improving Fuel Efficiency of Weapons Platforms (2001)
- Steps DOD has taken to implement recommendations from the reports
- Additional steps planned to implement recommendations from the reports
- Reasons why DOD has not implemented and does not plan to implement certain recommendations from the reports

Leadership and Culture Change

"Leadership is about vision, inspiration, values, and culture. Management is about systems, processes, resources, and policies. Organizational structure can, by itself, preclude success, it cannot, by itself, ensure success."[2]

True culture change of any large organization must start at the top. Edgar H. Schein is Sloan Fellows Professor of Management Emeritus and a senior lecturer at the Sloan School of Management at the Massachusetts Institute of Technology. In his book, *Organizational Culture and Leadership,* he tackles the complex question of how an existing culture can be changed – one of the toughest challenges of leadership.

According to Schein, as an organization matures, it develops a positive ideology and a set of myths about how it operates. The organization continues to operate by the shared tacit assumptions that have worked in practice, "and it is not unlikely that the espoused theories, the announced values of the organization come to be, to varying degrees, out of line with the actual assumptions that govern daily practice."[3] In the case of DOD energy use, this assumption would be the assumption that energy is cheap, plentiful, and for someone else to worry about.

Where these differences exist, scandal and myth explosion become relevant as mechanisms of culture change. Left to themselves, change will not occur "until the consequences of the actual operating assumptions create a public and visible scandal that cannot be hidden, avoided, or denied."[4] Recent examples include changes in NASA's safety culture following the *Challenger* and *Columbia* disasters or the Army's recent health care shakeup following the exposure of substandard administrative handling of wounded soldiers and conditions at certain Walter Reed Army Medical Center facilities. The DOD cannot afford to wait for an energy related scandal before initiating change.

Schein proposes that leaders can systematically set out to change how a large, mature organization operates recognizing such change may involve varying degrees of culture change. In short, it involves unlearning old behaviors and relearning new behaviors, and cannot be done

unless some sense of threat, crisis, or dissatisfaction is present to create the motivation to start the process of unlearning and relearning.[5]

"The change goal must be defined concretely in terms of the specific problem you are trying to fix, not as a 'culture change'…Culture change is always transformative change that requires a period of unlearning that is psychologically painful."[6]

President Bush has addressed dependence on foreign oil as a National Security issue in his 2006 and 2007 State of the Union addresses. Unfortunately, every President since Richard Nixon has had some initiative to improve energy security without much success. Any perceived threat was either not threatening enough or not long enough in duration to induce an American culture change with regard to energy.

Perhaps the current threat to energy security is different. The United States is more dependent than ever on foreign oil. US relations with the Middle East are strained, and China and India are booming economically with a corresponding need for energy.

An excellent way to demonstrate a DOD need for change is for the Secretary of Defense to deliver a high-profile speech on Energy security at a public venue, such as a Service academy graduation, supporting the President's energy initiatives, highlighting the importance of DOD energy security, and announcing the goals of a new comprehensive DOD Energy Strategy and the establishment of the Assistant Secretary of Defense for Energy Security. There should be no doubt in anyone's mind that the leadership at the highest levels is behind the transformation towards energy security. The Secretary should challenge leaders at all levels in the department to create incentives, remove disincentives, and seek out bold and innovative ways to reduce energy consumption, improve processes and efficiencies, and diversify energy sources as a National Security issue. The Secretary should also make it absolutely clear that showy, knee jerk

solutions such as lowering the thermostats in the winter and forcing people to wear jackets in their offices, will not be tolerated as acceptable methods of reducing energy use.

There is little current incentive for DOD personnel to reduce energy consumption. In fact, there are disincentives in place. Most military leaders quickly learn in an organization always looking for places to cut budgets and personnel, demonstrating an organization can do without is a sure way to lose money or personnel. The Air Force Flying Hour Program serves as an example.

A flying squadron commander allocated 8,000 flying hours to conduct his mission and keep his aircrews properly trained in their aircraft who manages on 7,600 hours can expect a 7,600 hour allocation next year. Instead of being rewarded for saving taxpayers dollars, units perceive the cuts as a punishment. The commonly accepted solution is to find a way to fly the hours at the end of the fiscal year vice falling short of the allocation. This is a "use it or lose it" culture.

It is difficult to save energy if you don't know how much you are using. Most military bases today do not measure energy consumption at each building. The Energy Policy Act of 2005, Section 103, directs federal agencies to meter electricity use in all (to the maximum extent practical) federal buildings by 1 October 2012, using advanced meters or metering devices that provide data at least daily. The DOD has a plan to meet this requirement, but under the "maximum extent practical" caveat many older buildings will never be metered.[7] Commanders should monitor energy consumed at their facilities and set goals for reduction. Energy savings should be rewarded, and excessive consumption should be investigated and corrected.

The first step towards culture change occurs by educating personnel and providing incentives and rewards to commanders who find ways to conduct their mission, properly train their personnel, and still save flight hours (read energy); or question why the hangar doors are

left open in the winter or why the office lights were left on overnight because it supports an Energy Strategy that strives to reduce energy consumption. The DOD will have affected a culture change when commanders instinctively know they are accountable for energy consumption, they know efficiency is its own "effect" in increasing combat capability, and they continually strive to improve efficiency because energy is a consideration in all military activities and operations. Only then will energy efficiency be a defining characteristic of DOD operations and facilities.

Innovation and Process Efficiencies

In March 2006, Secretary of the Air Force, Honorable Michael W. Wynne, announced *Air Force Smart Operations 21 (AFSO 21)*, a dedicated effort to maximize value and minimize waste in Air Force operations. AFSO 21 is a leadership program for commanders and supervisors at all levels, looking at each process from beginning to end. It doesn't just look at *how* the Air Force can do each task better, but asks the tougher and more important question: *Why* are things done a certain way? Is each of the tasks relevant, productive and value added?[8]

The Air Force has assembled an AFSO 21 team specifically to evaluate the core mission area "Conduct Air, Space, and Cyber Operations" (CASCO.) The CASCO team identified $750 million in potential fuel savings[9] by improved processes such as:

- Aircraft weight reduction (removal of non-critical equipment)
- Increased use of simulators for flying training and currency
- Reduced aircraft rotations to Iraq and Afghanistan
- Basing aircraft closer to operating areas
- More direct aircraft routing through improved diplomatic over flight clearances
- Fuel efficient ground operations
- Eliminating unnecessary air refueling[10]

Headquarters Air Mobility Command (AMC), responsible for organizing, training and equipping the USAF's air mobility platforms (C-5, C-17, etc.) is taking actions to improve

efficiency of flight operations by directing units to stop refueling aircraft without first knowing the required fuel load for the next mission. Air Force flying operations account for 82% of its fuel use, with Mobility Operations consuming the single largest slice (42%.) Data collected on one C-17 unit conducting stateside operational missions showed aircraft departed with an average of 58,000 lbs more fuel than the mission required due to standard ramp fuel loads.[11] The cost of carry extra weight in aircraft is enormous. The AMC standard cost of 100 lbs of weight across the Mobility Air Forces (MAF) fleet is $680,000 per year, or 1.42 million lbs of fuel.[12]

The ASD for Energy Security should lead a Department wide effort similar to AFSO 21 for fuel savings in other Service aviation programs, maritime operations, ground vehicle operations and facilities energy use. In baseball terms this is simply playing smarter, like good base running, hitting the cutoff man, and throwing ahead of runners instead of behind them.

Reduce Demand

Efficiency in Platforms - Aviation

Investing in efficiency is one of the most cost effective ways to save energy. Recent technology advancements in aviation have been significant. Boeing's new 787 "Dreamliner" represents a 70% improvement in fuel efficiency (cost/passenger mile) over their original 707 (KC-135) jet transport production aircraft.[13] DOD should investigate the many factors contributing to improved efficiency in aircraft, and those proving to be life-cycle-cost effective should be modified. In baseball terms this is like a sacrifice bunt. Sacrifice the batter now (spend money on re-engining) to move runners into scoring position (save money on fuel and gain efficiency/combat effectiveness later).

The "low hanging fruit" for improving efficiency on older aircraft is re-engining or modifying existing engines. This is particularly true for large nonfighter aircraft, as the

commercial aviation market, where fuel costs now exceed labor costs, has demanded higher efficiency engines in recent decades. Unfortunately, there is no corresponding commercial market for high performance afterburning engines used on fighter aircraft.

It should be noted however, that re-engining an aircraft is expensive and can impact all major aircraft systems and the training support structure. The cost of implementation may include reanalysis, redesign, or recertification of major aircraft systems to include cockpit controls and instrumentation, bleed air systems, hydraulic systems, electrical systems, aircraft structure, as well as developing and training new maintenance operations, publishing new technical manuals, training aircrews on new systems, and modifying training courseware and simulators as required. In short, re-engining is no simple task.

Through a contract awarded in 1979, the Air Force successfully re-engined 410 KC-135A "Stratotakers," first delivered in 1957, to the KC-135R configuration. This effort yielded 50% more fuel offload capability, 25% increase in fuel efficiency, 25% decreased operational cost, and a 96% noise reduction.[14] The re-engined fleet of KC-135s saves the AF between 2.3 – 3.2 million barrels of fuel annually.[15]

In 2006 the Air Force tasked the National Research Council (NRC) to examine and assess options for improving engine efficiency of all large nonfighter aircraft in its fleet. Improved engine efficiency can result in either better performance or decreased fuel consumption or both. For the purposes of the NRC report the primary objective of modifying or re-engining aircraft is to reduce fuel consumption. However, the report also highlighted numerous additional benefits that must be considered such as aircraft performance improvements, reduced maintenance, improved reliability and safety, and reduced environmental impact. Additionally, the report addressed the cost of modifying or re-engining aircraft, as well as timing, as significant

constraints. “While decisions should be based on economic benefit/cost analysis, they must also consider some of the benefits that cannot be easily monetized, such as performance improvements and national security. It may be the case that a greater good argument prevails, with the decision being made on more than just economic grounds, and that the controlling variable is saving fuel – not at any cost but at a reasonable cost.”[16]

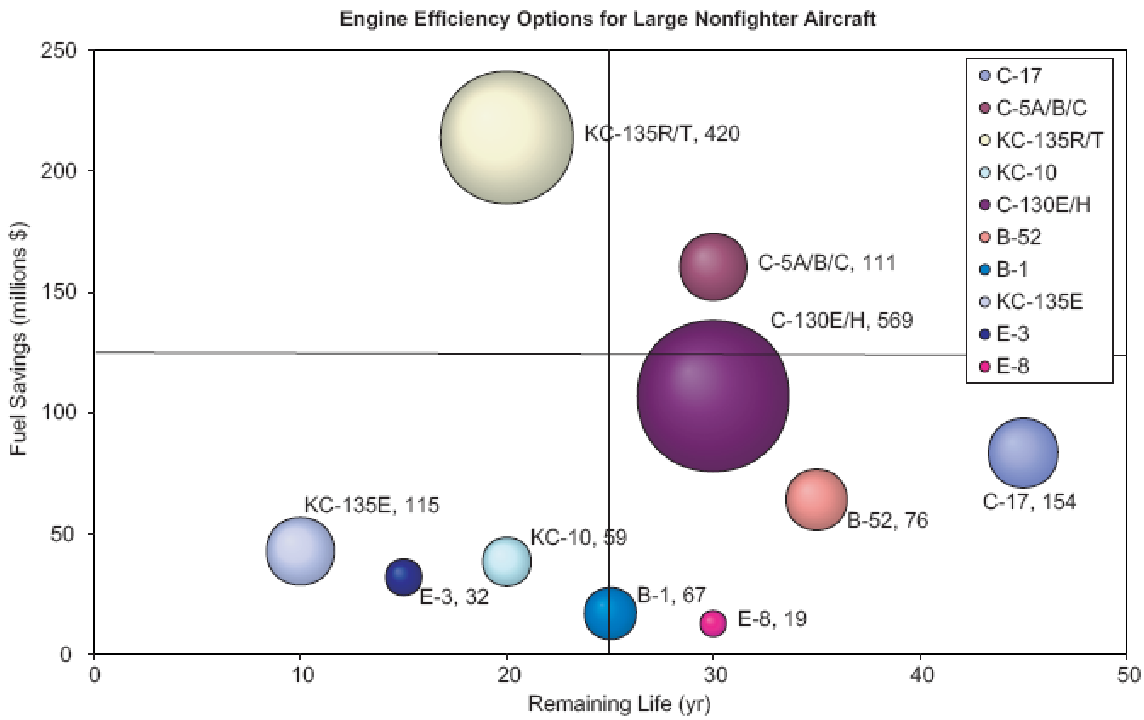


Figure 9 Engine Efficiency Options for Large Nonfighter Aircraft. ***Copyright © National Academy of Sciences. Permission is granted for this material to be shared for noncommercial, educational purposes, provided that this notice appears on the reproduced materials, http://www.nap.edu/catalog.php?record_id=11837.***

Figure 9 from the NRC study depicts selected large nonfighter aircraft potential fuel savings (based on a fuel price of $2.14 per gallon), and shows the most favorable modification/re-engine options in terms of improved efficiency and reduced consumption based on 2005 utilization rates, expected remaining service life, and fleet size (represented by proportional sized bubble diameter).[17]

The committee concluded there are a number of modification and re-engining options that deserve careful consideration and might pay for themselves. Key recommendations included:[18]

- The Air Force should study the potential upgrade of the KC-135R/T fleet with the fuel burn improvement modifications proposed under Service Life Extension Program (SLEP) for the F108 engine.
- The Air Force should pursue re-engining the C-130H on a priority basis, since this aircraft is one of the largest users of fuel in the Air Force inventory. The Air Force should use a competitive bid procurement process to provide the background for a decision on the C-130H models between the AE 2100 and PW150 engine options, either of which would appear to be acceptable on a technical and performance basis, and it should review the economics of engine efficiency upgrades to the older models with a shorter remaining service life.
- In general, where commercial engine/airframe counterparts exist (KC-10/DC-10, etc.), the Air Force engine and weapons system planners, managers, and policy makers should closely monitor the engine's original equipment manufacturers' and commercial operators' activities and actions relative to re-engining and engine modification as a measure of the cost/benefit for these activities.
- The Air Force should approach re-engining of the aircraft powered by the various models of the TF33 engine on a holistic basis with the goal of removing the engine(s) from the inventory.

The case for replacing the TF33 family of engines is particularly compelling. The Air Force currently has approximately 2,300 TF33 engines of various models used mainly on the KC-135E, E-3 AWACS, E-8 JSTARS, and the B-52H. The TF33 was designed in the 1950s and is one of the oldest engine families in the Air Force inventory. Since FY03, the TF33 depot overhaul cost has increased by 300%, to $1.25 million per engine in FY06. The very long on-wing lives of modern commercial transport engines (potentially 10,000 hours or more on-wing compared to 1,500-2,000 for the TF33) would significantly reduce the cost of engine ownership.[19]

With the exception of the B-52H, all of the TF33 powered aircraft are KC-135 variants or derivatives. Given that the majority of the KC-135 fleet has already been re-engined in the KC-135R program, and the E-8 JSTARS is now in re-engining source selection, a portion of the nonrecurring engineering costs may be shared among platforms rather than duplicated.[20]

Lastly, if the TF33 engines were eliminated from the inventory, then $800 million in TF33 inventory could be disposed of and the TF33 support structure of 188 personnel and 82,000 square feet of support real estate could be used for other Air Force needs.[21]

"Taken together, these considerations strongly suggest that TF33-powered aircraft should be considered as a group rather than subjected to the traditional approach – i.e., airframe by airframe studies. In this case, the whole savings from re-engining all TF33 aircraft my considerably exceed the sum or re-engining the individual platform types."[22]

The Defense Science Board, sponsored by USD (AT&L), conducted a study led by Michael P.C. Cairns, Gen, USAF (retired), in late 2002 and produced an updated version in 2004 on re-engining the USAF B-52H fleet. This study was the fourth look at re-engining the B-52H fleet since 1996. The first three Air Force studies concluded re-engining was not economically justifiable. However, several assumptions drove the decisions: constant fuel prices, engine depot repair costs would remain stable through 2037, the Air Force's judgment that required funding would lose out to higher priorities, and the possibility of premature B-52H retirement and force reductions to be unacceptable program risks.[23] The intent of this paper is not to challenge the USAF decision to not re-engine the B-52H fleet, but instead to highlight one example of what more efficient engines can provide in the way of energy savings and other operational and environmental gains.

The DSB study concluded that B-52H re-engining would reduce overall fuel consumption by about 35% and in-flight refueling demand by between 50-66%. The DSB task force scenarios estimated overall savings of nearly $8 billion through 2037 in reduced fuel demand, including reduced demand on existing tanker assets.[24]

A modern turbofan engine on the B-52H would also yield significant aircraft performance. Boeing estimates that unrefueled range will increase by 46%. A 10,000 mile B-52H mission (US to Afghanistan and return) would require only one in-flight refueling instead two, and require 158Klbs less fuel. On a typical Diego Garcia to Afghanistan mission, a 46% range increase would produce the combined benefits of accomplishing the mission with 66% reduced tanker demand plus 4.7 hours of loiter time. Additionally, emissions of carbon dioxide, carbon monoxide and smoke would decrease by 30% (oxides of nitrogen would increase by a factor of two), and community noise impacts would be reduced significantly.[25]

The available energy of its fuel limits any propulsion system. One pound of JP-8 jet fuel has enough energy to produce 7.2 horsepower for 1 hour. Thermal efficiency defines the amount of fuel available energy that is converted to horsepower for a real engine. Present day gas turbine engines can convert about 40% of the available fuel energy. Overall efficiency of jet propulsion systems defines how much of the fuel available energy is converted to useful thrust. There are also inherent losses in converting mechanical power to jet thrust. Today's engines are constrained to provide either fuel efficiency or high performance. Modern high bypass turbine engine transport aircraft are about 30% efficient in converting available fuel energy into thrust. Fighters and bombers typically convert 20-25% to useful thrust. So there is plenty of room for efficiency improvements in the gas turbine engine.[26]

There are promising future engine efficiency programs underway in a cooperative government and industry effort. VAATE (Versatile, Affordable, Advanced Turbine Engines) is the national turbine engine technology plan that will provide the future propulsion capability US war fighters need to combat changing threats to security. Comprised of all sectors of the Department of Defense, NASA, the Department of Energy, six major engine companies and

three airframe manufacturers, VAATE is a totally integrated, physics-based, turbine engine technology program chaired by OSD. The program includes technical activities, which will improve turbine engine capabilities beyond those of a year 2000 baseline engine while reducing all facets of engine cost. VAATE is a three-phase technology program with a defined goal set that will produce a 10X improvement in affordable turbine engine capability by 2017. VAATE engines will reduce engine thrust specific fuel consumption by as much as 25%.[27] VAATE represents a promising young minor league baseball prospect that will do great things in the future.

NRC is studying several other efficiency approaches to saving fuel by modifying existing aircraft, including aircraft winglets, laminar flow nacelles, optimization of operations, engine build practices, information use, and engine water washes.[28] Aircraft efficiency factors with promising potential for fuel savings on future designs include improved blended wing body designs, and reduced weight through use of composite materials and more efficient structural design, and improved aircraft systems (e.g. reduced weights via increased electrical systems vs. hydraulic and bleed air systems.)

Efficiency in Platforms – Maritime

Like aircraft, maritime platforms have made progress in efficiency over the years. The Navy gained a 15% increase in fuel efficiency on selected ships through the use of stern flaps and bulbous bow technology on surface ships. The stern flaps create lift to the aft portion of the ship and reduces propeller cavitations. This results in reduced hydrodynamic drag and improved efficiency. The Navy projects 7.5% net annual fuel savings on *Arleigh Burke* class guided missile AEGIS destroyers saving almost $195,000 per year per ship. Use of the bulbous bow to

reduce drag by lowering the wave-making resistance of the ship's hull can save an additional 4% in fuel use, with a yearly fuel savings of approximately 100,000 gallons per year per ship.[29]

The Navy also has existing studies about converting current fossil fuel burning ships to nuclear power. As discussed in re-engining aircraft, changing propulsion systems on a ship is no easy task and would include extensive redesign and training. For each class of ship there is a corresponding price of oil where nuclear powered propulsion becomes economically feasible.

The civilian shipping industry is also seeing significant efficiency improvements through the use of silicon hull paints, saving up to 6% of fuel on container ships.[30] This could also have military applications.

Efficiency in Platforms – Ground Tactical Vehicles

> The nearly 70-ton M1A2 Abrams main battle tank – the outstanding fighting machine of US armored forces – is propelled at up to 42 mph on– or 30 mph off-road by a 1,500-hp gas turbine, and averages around 0.3-0.6 mpg. Its ~20-40 ton-mpg is surprisingly close to the ~42 ton-mpg of today's average new light vehicle; the tank simply weighs ~34 times as much, half for armor. But there's more to be done than improving its ~1968 gas turbine: for ~73% of its operating hours, Abrams idles that ~1,100-kW gas turbine at less than 1% efficiency to run a ~5kW "hotel load" – ventilation, lights, cooling, and electronics. This, coupled with its inherent engine inefficiency, cuts Abrams' average fuel efficiency about in half, requiring extra fuel whose stockpiling for the Gulf War delayed the ground forces' readiness to fight by more than a month.[31]

The most important factor in reducing the demand for fuel in vehicles is the weight of the vehicle. Heavier vehicles simply require more energy to move. The DOD recognizes the potential energy efficiency savings associated with lightweight materials and structures and is investing in materials research to provide high performance ground vehicles to meet warfighting needs and save energy.

The Naval Research Advisory Committee's April 2006 report, *Future Fuels,* recommended hybrid electric drive vehicles as the most effective and efficient way to lengthen the "tether of

fuel." The study found that fuel economy could improve by as much as 20% or more, and enable highly maneuverable and agile vehicle traction control both on and off-road, in covert or overt operations, and can provide mobile electric power.

The DOD should strive to accelerate ongoing efforts, including use of carbon-fiber reinforced composites, expanded use of titanium (40% lighter than steel), rethinking the use of armor to protect the occupants of the vehicle rather than armoring the entire vehicle, and development of a hybrid electric architecture for tactical wheeled vehicles.

The incredibly high utilization rate of tactical wheeled vehicles in OIF and OEF is wearing out equipment that will soon need to be replaced. It would be preferable to develop and acquire a fuel efficient replacement to the High Mobility Multipurpose Wheeled Vehicle (HMMWV or Humvee) now, instead of refurbishing or buying new Humvees which get only 4 miles per gallon in city driving conditions and 8 miles per gallon in highway driving conditions[32] and will continue to be inefficient for their potential service life of 20-30 years.

Increase Supply/Diversify Sources

Alternative Fuels

In coal-rich, oil-poor pre-WWII Germany, Franz Fisher and Hans Tropsch developed a process to produce liquid hydrocarbon fuel from coal that supplied a substantial portion of Germany's fuel during the war. The Fischer-Tropsch (FT) process is a catalyzed chemical reaction in which syngas (carbon monoxide and hydrogen produced from the partial combustion of coal which has been gasified and combined with molecular oxygen) is converted into liquid hydrocarbons of various forms. Typical catalysts used are based on iron and cobalt. Liquid hydrocarbon fuels produced from coal gasification and the FT process are intrinsically clean, as sulfur and heavy metal contaminants are removed during the gasification process. The principal

purpose of the FT process is to produce a synthetic petroleum substitute for use as synthetic lubrication oil or as *synthetic fuel*. The FT process can be used to produce liquid hydrocarbon fuel from virtually any carbon-containing feed stock, including low-grade tars, biomass, or shale oil; only the preprocessing steps would differ from the gasification process used with coal.[33]

Since the United States has the largest coal reserves in the world, synthetic fuel, or synfuel, made from coal is particularly appealing. Synfuel represents a domestically controlled resource with prices theoretically tied to the coal market instead of the world oil market.

South Africa has been producing synthetic fuel for decades and many consider it to be a mature technology ready for commercialization. Why then, has the synfuel market not boomed and produced billions of gallons of fuel for US energy needs? Until recently, the answer has been financial risk.

Congress approved the Synthetic Liquid Fuels Act on April 5, 1944. The Act authorized $30 million for a five-year effort for:

"...the construction and operation of demonstration plants to produce synthetic liquid fuels from coal, oil shales, agricultural and forestry products, and other substances, in order to aid the prosecution of the war, to conserve and increase the oil resources of the Nation, and for other purposes."[34]

In 1948, Congress extended the project to eight years and doubled funding to $60 million. In the end, synthetic fuel from coal could not compete economically with gasoline made from crude oil, especially given the major oil reserve discoveries in the Middle East at the time. In 1953, Congress terminated funding and closed the plants.[35]

At the height of the 1979 oil crisis, when the United States imported approximately 25% of its crude oil, President Jimmy Carter proposed an Energy Security Corporation that would use

$88 billion of windfall profits tax on domestic oil producers to subsidize development of 2.5 million barrels per day of synthetic fuels production. After much debate, Congress passed the Energy Security Act of 1980. The law created a US Synthetic Fuel Corporation with an initial budget of $17 billion. After four years the corporation would submit a "comprehensive strategy" for congressional approval, where the balance of $68 billion would be made available. A combination of mismanagement, administration change from President Carter to President Reagan, and most significantly, crude oil prices falling from a 1981 peak of $36 per barrel to $12 in 1986, effectively killed the US Synthetic Fuel Corporation.[36] Of the 67 projects proposed in 1981, only a few carried design efforts far enough to maturity. Bad business risk became the stigma attached to synthetic fuels.

In 2006 the Secretary of the Air Force directed a project to procure synthetic jet fuel for ground testing and, if ground tests were successful, flight testing.[37] In December 2006, a B-52 conducted a flight-test mission using a 50/50 blend of manufactured synthetic fuel and petroleum based JP-8, or synfuel-blend, on all eight engines, and recently finished cold-weather testing at Minot AFB, ND, the last step in the testing and certification process. Test data is being analyzed, and the final test report is scheduled to be released in June 2007. Thus far, results have been positive. The Air Force is committed to completing testing and certification of synfuels for its aircraft by 2010, and aims to acquire 50% of CONUS fuel from a synfuel-blend produced domestically by 2016. At current consumption rates this equals approximately 325 million gallons of synfuel-blend.[38]

This will certainly not eliminate US dependence on foreign oil, but is comparable to a double or triple in the George Shultz baseball analogy cited at the beginning of this chapter. Subsequent actions, such as proving the economic viability of synfuels, or improving upon FT

process could "bring these runners home" and further expand domestically produced energy supplies.

Could the world's single largest energy consumer be the catalyst to successfully launch a new synthetic fuel industry in the United States? Advocates say with government help FT technology could supply 10% of US fuels within 20 years.[39]

A relatively small synthetic fuel plant, processing 17,000 tons per day of coal to produce 28,000 barrels per day of fuel, 750 tons per day of ammonia, and 475MW of net electrical power would cost approximately $3 billion.[40] Ten to fifteen such plants could supply all of the DOD's fuel requirements.

Senators Jim Bunning and Barack Obama have introduced legislation to address the need to pull together the investors and the billions of dollars need to build a synthetic fuel plant by expanding and enhancing the DOE loan guarantee program included in the Energy Policy Act of 2005; providing a new program of matching loans to address funding shortages for front-end engineering and design (capped at $20 million and must be matched by non-federal money); expanding investment tax credit and expensing provisions, and extending the fuel excise tax credit; providing funding for the DOD to purchase, test, and integrate synfuels into the military; authorizing a study on synfuel storage in the Strategic Petroleum Reserve; and perhaps most importantly to reduce financial risk associated with starting a US synthetic fuel industry, extending existing DOD contracting authority for up to 25 years.[41]

Long-term contracts move much of the financial risk from private investors to the American taxpayers. If there were a long-term decline in the price of oil, the DOD could potentially pay much higher prices for synthetic fuel than they would otherwise pay for petroleum products. In

past years, the DOD has not had the authority to enter into the 15- or 25-year deals industry wants.

In his keynote address to the March 2007 USAF Energy Forum in Washington DC, Senator Bunning addressed the issue: “I believe the DOD should be authorized to pay a premium for high-quality, clean, domestic fuel. Long-term contracts will provide price certainty and allow for more consistent budgeting. These contracts will vary above and below market prices as world oil prices change during the life of a 25-year contract. I believe this is healthy and normal for long-term contracts.”

Secretary Wynne also addressed price stability at the Energy Forum. “Last year, the AF spent about $6.6 billion on aviation fuel; 1.6 billion dollars more than budgeted. In 2005, the fuel budget was $1.4 billion more than the previous year.

We could have paid for a supplier to build a dedicated coal, natural gas, or other derived fuel plant with this $3 billion in unbudgeted expense. Maybe then we could have a predictable cost for fuel.”

A coal-based synthetic fuel industry also has significant environmental burdens to overcome. Synfuel plants consume huge quantities of water, both as part of the coal conversion process and for cooling. A typical plant consumes about 3.5 barrels of water for each barrel of synthetic fuel produced. Water is a potentially limiting factor for building synfuel plants in many coal-rich western states like Wyoming and Montana.[42]

An even bigger environmental issue is the amount of carbon dioxide (CO2) produced by refining coal can be 50-100% higher than refining petroleum.[43] Advocates for synfuel point out the CO2 can be captured and used for “enhanced oil recovery” by pumping the captured CO2 into oil wells to retrieve otherwise unobtainable oil, or sequestered in underground saline

aquifers or other “storage” locations to prevent addition of CO_2 to ever-increasing GHG problem. Skeptics are quick to point out that carbon capture and sequestration has never been proven on any large scale, and if attempted, would surely add to the cost of synfuel production.

Global warming due to GHG emissions has become the political 500 pound gorilla that cannot be ignored. Secretary Wynne acknowledged this in his address to the USAF Energy Forum:

> The big issue is the sequestration of large amounts of carbon dioxide before it’s released into the atmosphere. The DOE National Energy Technology Laboratory and several others are now working on the development of carbon capture technology that approaches 90%.
>
> Our team at Wright-Patterson also is working on a study with DOE to find the right mix of biomass and coal to reduce CO_2 emissions starting with the feedstock.
>
> We aim to be good stewards of the environment and yet push for the production and purchase of domestically produced synfuel from plants that use coal, natural gas or other derivation that incorporate greenhouse gas reduction processes to provide the right fuel in the right manner.

The DOD could not only be the catalyst for the synthetic fuel industry in the United States, but could also promote US carbon capture and sequestration on an unprecedented scale. The DOD should not support any synfuel initiatives that do not responsibly handle CO_2 emissions.

Ethanol is an important alternative to petroleum based gasoline in the larger national strategy to reduce oil consumption, and the DOD should follow government guidelines in purchasing new non-tactical vehicles capable of operating on ethanol or other alternatives to gasoline. However, gasoline represents on 1.1% of DOD energy costs and aggressive pursuit of ethanol for the DOD will not make a significant difference.

DOD Facilities and Renewable/Nuclear Energy Sources

As discussed in Chapter 2, DOD facilities energy management could serve as a model for the rest of the federal government. DUSD (I&E) manages an excellent facilities energy program. Facilities are unique in that efficient facilities can reduce energy demand and renewable energy initiatives on or near DOD installations can also increase supply and diversify sources.

The DOD is one of the major leaders of the federal government in renewable energy, receiving about 9% of electricity from renewable sources in FY 2005 (national average is 6%) and has a goal of 25% of electricity from renewable sources by 2025.[44]

Why not a more aggressive goal? DOD should set a goal of being a net-zero energy consumer at its facilities by 2030. The path to net-zero energy consumption is through expanded production of renewable, and possibly nuclear, energy sources at or near DOD installations.

Several DOD installations are already exceeding the existing 25% renewable goal. Dyess AFB, TX is operating 100% on renewable energy, with Minot AFB and Fairchild AFB not far behind with 95.7% and 99.6% respectively.

Other energy saving or renewable energy projects are already established or underway at many DOD installations. At Nellis AFB, NV, the Air Force recently awarded a contract to build the largest photovoltaic solar farm in the world, on track to generate 18MW in late 2008.[45] A 2004 Sandia National Laboratory study concluded that nearly all DOD installations have potential for one or more economically viable solar energy projects with potential savings of 10% in electricity and 14% in natural gas.[46]

Geothermal energy has been a success story for the Navy. Geothermal energy is found in underground pockets of steam, hot water, and hot dry rocks. Steam and hot water can be extracted from underground reservoirs to power steam turbines, which drive generators and

produce electricity. Lower intensity geothermal resources are used for direct-use applications such as space heating, and by geothermal heat pumps to heat and cool buildings.

The Navy has four privately built, owned, and operated geothermal power plants at Naval Air Warfare Center China Lake, CA,[47] and is building another at Naval Air Station Fallon, NV. The private company sells the electricity to a utility company and pays the Navy. The Navy has received an average of $14.7 million annually from 1987-2003. The navy spent about two-thirds of its geothermal revenues on energy conservation projects, including solar energy systems. About one-third of the revenues funded the overhead costs of the Navy's Geothermal Program Office. The geothermal plant at China Lake has been producing 345,000 MWh of electricity per year since 1990.[48]

The DOD has identified four additional installations as good candidates for geothermal power generation that might be commercially viable, third party funded, producers of an average of 40 MW annually (MWa) of electricity. Six to eight additional installations have hot water potential and will be researched further.[49]

Geothermal heat pumps are similar to ordinary heat pumps, but use the ground instead of outside air to provide heating, air conditioning and, in most cases, hot water. Because they use the earth's natural heat, they are among the most efficient and comfortable heating and cooling technologies currently available. The Services have installed a total of 10,356 geothermal heat pumps among 24 different installations since 1993.[50]

In 2005, Naval Station Guantanamo Bay brought online the world's largest wind farm/diesel hybrid power system. The plant is rated at 3.8 MW, is improving installation grid reliability, providing 25% of the base's power requirements, and saving the Navy $1.2 million annually.[51]

Since 1997, the Air Force has installed five wind generation facilities producing 8400 KW of electricity. The Army has two small wind facilities, generating 335 KW, and the Navy has one wind facility at San Clemente Island, CA, rated at 675 KW.[52] The DOD has identified an additional 109 facilities with the potential to produce an additional 70 MWa in wind energy.[53]

Renewable energy production at DOD facilities is growing and must continue to grow in order to assure access to critical energy requirements. Renewable energy diversifies energy sources and provides cost effective, environmentally responsible energy to DOD facilities.

Nuclear Power

Another more controversial energy source with great potential to provide assured access to electricity for DOD installations is nuclear power. Secretary of Energy, Sam Bodman announced the Global Nuclear Energy Strategic Partnership (GNEP) in February 2006 as part of the President Bush's Advanced Energy Initiative highlighted in the 2006 State of the Union Address.

The purpose of GNEP is "…to work with other nations to develop and deploy advanced nuclear recycling and reactor technologies. This initiative will help provide reliable, emission-free energy with less of the waste burden of older technologies and without making available separated plutonium that could be used by rogue states or terrorists for nuclear weapons. These new technologies will make possible a dramatic expansion of safe, clean nuclear energy to help meet the growing global energy demand."[54]

In short, GNEP is about expanding nuclear power capabilities with advanced technologies to effectively and safely recycle spent nuclear fuel without producing separated plutonium. Once the technology is demonstrated it can be exported to other countries.

If GNEP proceeds as planned, DOE will have to test and validate these new nuclear technologies. Larger DOD installations, especially those with limited renewable energy capabilities, could provide the DOE secure sites to validate the new technologies before sending it overseas. The DOD would gain nuclear powered installations independent from the vulnerable, fragile commercial electric grid. Additionally, DOD could provide surplus power to surrounding civilian communities.

It will likely be a slow process, but the DOD can develop a comprehensive energy strategy and create an organizational structure for implementation. Through culture change, process innovations, efficiencies, and alternative energy sources the DOD can re-tool itself with regard to energy.

---

[1] Armed Forces, Title 10 USC, Sec. 131.

[2] Slife, James C., Colonel USAF, Officer Professional Development session on Leadership and Management, The Pentagon, Washington DC, 2 February 2007.

[3] Schein, *Organizational Culture and Leadership,* 309.

[4] Ibid., 310.

[5] Ibid., 324.

[6] Ibid., 334-335.

[7] Hancock, Brad, CDR, USN, OSD AT&L, email to author.

[8] Wynne, "Letter to Airmen: Air Force Smart Operations 21."

[9] HQ USAF, Air Operations Operational Planning, 16.

[10] Clary, Air Force Aviations Operations.

[11] Peterson, to AMC OG/CCs, memorandum.

[12] James, Bullet Background Paper on Hawaii ANG.

[13] Muellner, USAF Energy Forum.

[14] KC-135 Fact Sheet, http://www.af.mil/factsheets/factsheet.asp?fsID=110 (accessed 12 March 2007).

[15] Boeing, KC-135 Homepage.

[16] National Research Council, *Improving the Efficiency of Engines*, 1.

[17] Ibid., 2.

[18] Ibid., 1, 3-4.

[19] Ibid., 42-43.

[20] Ibid., 42-43.

[21] Ibid., 43.

[22] Ibid., 43.
[23] Defense Science Board, *Defense Science Board Task Force on B-52H*, ES-1.
[24] Ibid., ES-2.
[25] Ibid., ES-4.
[26] Stricker, USAF Energy Forum.
[27] Ibid.
[28] National Research Council *Improving the Efficiency of Engines*, 1.
[29] House. *Hearings before the Subcommittee on Terrorism*, 13.
[30] http://www.international-marine.com/news/news_items/New%20Intersleek%20900.pdf
[31] Lovins, *Winning the Oil Endgame*, 86.
[32] Donnelly, "Military Wants a More," A1.
[33] Office of the Assistant Secretary of the Navy, *Future Fuels*, 55.
[34] Department of Energy, *The Early Days of Coal*.
[35] Ibid.
[36] Yanarella, *The Unfulfilled Promise of Synthetic Fuels*; 193.
[37] House. . *Alternative Energy and Energy Efficiency*, 3.
[38] Wynne, USAF Energy Forum.
[39] Schmidt, "A Reluctant Pentagon Viewed."
[40] Office of the Assistant Secretary of the Navy, *Future Fuels*, 56.
[41] Bunning, USAF Energy Forum.
[42] Goodell, *Big Coal, The Dirty Secret*, 221.
[43] Ibid., 221.
[44] House. *Hearings before the Subcommittee on Terrorism*, 9.
[45] Wynne, USAF Energy Forum.
[46] Sandia National Laboratories, DOD Solar Energy Assessment.
[47] US GAO, *Geothermal Energy: Information on the Navy's Geothermal Program*, i
[48] Department of the Navy, *FY 2005 Annual Energy Management Report*, 6
[49] Office of the Secretary of Defense, *DOD Renewable Energy Assessment*, 3-4
[50] Tri-Service Renewable Energy Committee Project Listing, 1-3
[51] Department of the Navy, *FY 2005 Annual Energy Management Report*, 4
[52] Tri-Service Renewable Energy Committee Project Listing, 1-3
[53] Office of the Secretary of Defense, *DOD Renewable Energy Assessment*, 3
[54] White House. *The National Security Strategy*, 29.

Chapter 5 – Conclusion

> *For more than two decades, federal energy policy has been afflicted by paralysis. Although much energy legislation has been passed into law during this period, America's energy security has grown worse with each passing year. This deteriorating condition has created enormous economic and national security vulnerabilities…*
>
> *The time for action arrived long ago. We must not waste another moment.*

Energy Security Leadership Council
Recommendations to the Nation on Reducing US Oil Dependence
December 2006

This paper has attempted to objectively address the US National Security problem of deteriorating energy security from a Department of Defense perspective. Energy is the life blood of the US economy and the key enabler of US military combat power.

The United States' unique ability to project military power anywhere on the globe requires incredible quantities of liquid hydrocarbon fuel. Today, the primary source of fuel is imported oil from an economically and politically unstable world oil market.

The true cost of fuel is much more than it appears on the purchasing receipt. The DOD's never ending need for fuel comes with a high price tag which includes not only the bulk purchase price of the fuel itself, but also the cost of a fuel logistics system that includes tens of thousands of personnel, storage facilities, tanker trucks, and major weapons systems such as the KC-135 whose primary mission is to deliver fuel. Additionally, fuel has a significant cost in combat capability that is almost impossible to quantify.

There are numerous outstanding energy programs within the Department of Defense. Rising energy costs have given new emphasis to saving fuel in each of the Services, and the DOD

facilities energy management program is a model for the federal government. Recent energy studies by military and energy experts provide volumes of recommendations to improve efficiency and save energy. However, there is no existing comprehensive DOD Energy Strategy, and no single energy senior official or energy advocate in the Department.

The military's dependence on vast amounts of fuel and electricity creates vulnerabilities. Disruption in the flow of fuel and electricity due to natural disaster, sabotage or physical attack on the petroleum or electricity infrastructure cannot be dismissed as an unlikely event. Also, the fact that so much of US and other countries energy needs rely on imported oil creates foreign policy and economic vulnerability.

To improve energy security the DOD needs a comprehensive Energy Strategy that:

- Improves National Security by decreasing US dependence on foreign oil
- Ensures access to critical energy requirements
- Maintains or improves combat capability
- Promotes Research for future energy security
- Is fiscally responsible to the American tax payer
- Protects the environment

Also required is an organizational structure to implement that strategy through the establishment of an ASD for Energy Security with policy and resource authority to serve as the Senior Official for energy issues in the Department. The ASD for Energy Security must implement the Department's Energy Strategy through:

- Leadership and culture change to make energy a consideration in all military actions and operations
- Innovation and process efficiencies as well as efficiency improvements in platforms and facilities to reduce energy demand
- Increased energy supply via alternative fuels and renewable energy programs

The Department of Defense can lead the way in transforming the way in which the United States consumes *and produces* energy. In the 1985 movie, *Back to the Future,* scientist Dr. Emmett Brown returns from the year 2015 with a 1980's vintage vehicle modified with a "Mr.

Fusion" device creating huge amounts of energy from organic material found in common household garbage. The year 2015 is only 8 years away and there is no evidence Mr. Fusion, or any major scientific breakthrough making oil obsolete, is going to happen inside the next 30 years. Mr. Fusion represents the fantasy of the game winning home run. In reality there are few home runs to reduce the United States' addiction to foreign oil.

Improving energy security must be done using a steady, incremental approach not tied to individual personalities, specific military leaders or partisan political administrations. Securing the energy future of the Department of Defense is a prerequisite to ensuring the United States remains the world's preeminent global power.

Bibliography

Air Force Press Release, "B-52 Flight Uses Synthetic Fuel in All Eight Engines," Release No. 031206, Dec 15, 2006.

American Society of Civil Engineers (ASCE), Infrastructure Report Card 2005, Energy, http://www.asce.org/reportcard/2005/page.cfm?id=25 (accessed 7 March 2007).

Armed Forces, US Code, Title 10, http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=browse_usc&docid=Cite:+10USC131 (accessed 6 March 07).

Blanchard, Christopher M., *Al Qaeda: Statements and Evolving Ideology*, CRS Report for Congress, Congressional Research Service, Library of Congress, 24 January 2007, http://www.fas.org/sgp/crs/terror/RL32759.pdf (accessed 13 March 2007).

Blum, Justin, "Hackers Target U.S. Power Grid," *Washington Post*, March 11, 2005, page E01.

Boeing, Integrated Defense Systems, KC-135 Homepage, http://www.boeing.com/defense-space/military/kc135-strat/index.html (accessed 1 March 2007).

Buchanan, Scott C., "Energy and Force Transformation," *Joint Forces Quarterly*, Issue 42 (3d Qtr 2006): 51-54.

Bunning, Jim, US Senator, Keynote Address to the Air Force Energy Forum on Coal-to-Liquid Fuel, Arlington, VA, 8 March 2007.

Clary, David, Maj Gen, USAF, Air Force Aviations Operations, PowerPoint presentation, 8 Jan 2007

Defense Energy Support Center, *Fact Book FY 2006*, http://www.desc.dla.mil/DCM/Files/FactBook_FY06.pdf (accessed 16 March 2007).

Defense Science Board, *Defense Science Board Task Force on B-52H Re-Engining*, Revised and Updated June 2004, http://www.acq.osd.mil/dsb/reports/2004-06-b52h_re-engining.pdf (accessed 7 March 2007).

Defense Science Board, *More Capable Warfighting Through Reduced Fuel Burden*, Jan 2001, http://www.acq.osd.mil/dsb/reports/fuel.pdf (accessed 1 March 2007).

Department of Defense, *Annual Energy Management Report, Fiscal Year 2006*, http://www.acq.osd.mil/ie/irm/Energy/energymgmt_report/fy06/FY_2006_Annual_Report_Narrative.pdf, January 2007 (accessed 15 March 2007).

Department of Defense, *FY 2000 Energy Management Data Report*, http://www.acq.osd.mil/ie/irm/Energy/energymgmt_report/fy00/fy00_exhibit55_final.pdf 10 January 2001 (accessed 15 March 2007).

Department of Defense, *FY 2001 Energy Management Data Report*, http://www.acq.osd.mil/ie/irm/Energy/energymgmt_report/fy01/FY01_DoD%20Exhibit%2055.pdf, 28 December 2001 (accessed 15 March 2007).

Department of Defense, *FY 2002 Energy Management Data Report*, http://www.acq.osd.mil/ie/irm/Energy/energymgmt_report/fy02/OMBCircularA-11.xls, 26 March 2003 (accessed 15 March 2007).

Department of Defense, *FY 2003 Energy Management Data Report,* http://www.acq.osd.mil/ie/irm/Energy/energymgmt_report/fy03/Final%20DoD%20DataReport.xls, 18 December 2003 (accessed 15 March 2007).

Department of Defense, *FY 2004 Energy Management Data Report*, http://www.acq.osd.mil/ie/irm/Energy/energymgmt_report/fy04/DoD%20Data%20Report%20Summary.xls, 21 December 2004 (accessed 15 March 2007).

Department of Defense, *FY 2005 Energy Management Data Report*, http://www.acq.osd.mil/ie/irm/Energy/energymgmt_report/fy05/Final%20FY%202005%20Data%20Report.pdf, 15 December 2005 (accessed 15 March 2007).

Department of Defense, *FY 2006 Energy Management Data Report*, http://www.acq.osd.mil/ie/irm/Energy/energymgmt_report/fy06/FY_2006_data_report.pdf, 20 December 2006 (accessed 15 March 2007).

Department of Energy, *Benefits of Using Mobile Transformers and Mobile Substations for Rapidly Restoring Electrical Service*, A Report to the United States Congress Pursuant to Section 1816 of the Energy Policy Act of 2005, August 2006, http://www.oe.energy.gov/DocumentsandMedia/MTS_Report_to_Congress_FINAL_73106.pdf (accessed 8 March 2007).

Department of Energy, *The Early Days of Coal Research*, http://www.fe.doe.gov/aboutus/history/syntheticfuels_history.html (accessed 14 March 2007).

Department of Energy, *The Electricity Delivery System*, Feb 2006, http://www.energetics.com/gridworks/pdfs/factsheet.pdf (accessed 11 March 2007).

Department of Energy, *Global Nuclear Energy Partnership Strategic Plan,* GNEP-167312, Rev. 0, Washington D.C, January 2007.

Department of the Navy, *FY 2005 Annual Energy Management Report*, https://energy.navy.mil/publications/annual_energy_summary/fy2005/DON%20FY05%20Annual%20Energy%20Management%20Report.pdf (accessed 7 February 2007).

Deutch, John, and Schlesinger, James R., *National Security Consequences of US Oil Dependency,* Council on Foreign Relations, Independent Task Force Report No. 58, New York, 2006

DiPetto, Chris, Energy Efficiency for Tactical Systems, PowerPoint Presentation to 2006 PEO/SYSCOM Commanders' Conference, http://www.dau.mil/conferences/presentations/2006_PEO_SYSCOM/wed/B3-DiPetto.pdf, 8 Nov 2006.

"DOD Promotes Energy Initiatives to Stretch Dollars, Improve Efficiency," *Congressional Quarterly*, Oct 4, 2006

"DOD Seeks Expanded Funding to Research Bio-based jet Fuel," *Inside Green Business Weekly Report*, Inside Washington Publishers, 1, No. 20 (13 September 2006).

Donnelly, John, "Military Wants a More Fuel-Efficient HUMVEE," *Boston Globe*, October 2, 2006, Pg. A1

Energy Information Administration, Country Analysis Briefs, *Persian Gulf Oil and Gas Exports Fact Sheet*, http://www.eia.doe.gov/emeu/cabs/pgulf.html (accessed 27 February 2007).

Energy Information Administration Website, http://www.eia.doe.gov/fuelelectric.html (accessed 14 February 2007).

Energy Information Administration, *Electric Power Annual 2005*, http://www.eia.doe.gov/cneaf/electricity/epa/epa.pdf (accessed 31 January 2007).

Energy Information Administration, *International Energy Annual 2004*, http://www.eia.doe.gov/pub/international/iealf/table12.xls, (accessed 28 Feb 2007).

Energy Information Administration, *International Energy Outlook 2006*, http://www.eia.doe.gov/oiaf/ieo/pdf/oil.pdf (accessed 1 Mar 2007).
Energy Information Administration, *Where Does My Gasoline Come From?*, EIA Brochures, http://www.eia.doe.gov/neic/brochure/gas04/gasoline.htm (accessed 1 Mar 2007).
Energy Security Leadership Council, *Recommendations to the Nation on Reducing US Oil Dependence,* A project of: Securing America's Future Energy, December 2006, http://www.secureenergy.org/reports/ESLC_Oil_Report.pdf (accessed 1 March 2007).
Fabey, Michael, "Pentagon Striving to Find Fuel Alternatives, Conserve Energy," *Aerospace Daily & Defense Report* 220, no. 3, (Oct 5, 2006), 1.
Fournier, Donald F. and Westervelt, Eileen T., *Energy Trends and Their Implications for US Army Installations, http://www.caesenergy.org/readingroom/d/usarmycorp-energy-trends.pdf*, September 2005.
Goldwyn, David L., "Energy Security: The New Threats in Latin America and Africa," *Current History* 105, no. 695 (December 2006), 441-446.
Goodell, Jeff, *Big Coal, The Dirty Secret Behind America's Energy Future,* Boston – New York, Houghton Mifflin Company, 2006
Grone, Philip W., Deputy Under Secretary of Defense (Installations & Environment), To Service Secretaries. Memorandum, 18 November 2005, http://www.acq.osd.mil/ie/irm/irm_library/Signed%20Installation%20Energy%20Goals%2018%20Nov%2005.pdf (accessed 1 March 2005).
Hershey, Robert D. Jr., "Synfuels Chief Under Fire: Edward E. Noble; Waiting for the Ax to Fall," *New York Times,* Section 3; Page 6, Column 3; Financial Desk, 17 June 1984
HQ USAF, Air Operations Operational Planning – Fuels Flying Training Migration to Aircrew Training Devices (ATDs)/ Optimization, PowerPoint briefing, 6-9 February 2007
MITRE Corporation, JASON Program Office, *Reducing DOD Fossil Fuel Dependence.* McLean, VA, September 2006.
James, Tom, Lt Col, USAF, Bullet Background Paper on Hawaii ANG KC-135 Weight Reduction Initiative, 10 January 2007.
Joint Publication 1-02, *Department of Defense Dictionary of Military and Associated Terms,* 5 Jan 2007 (as amended), http://www.dtic.mil/doctrine/jel/new_pubs/jp1_02.pdf
Lovins, Amory B., Lovins, L. Hunter, *Brittle Power,* Brick House Publishing Co., Inc., 1981, New edition copyright, Andover, MA, 2001.
Lovins, Amory B, E. Kyle Data, Odd-Even Bustnes, Jonathan G. Koomey, Nathan J. Glasgow, *Winning the Oil Endgame, Innovation for Profits, Jobs, and Security,* Snowmass, CO, Rocky Mountain Institute, 2005.
Muellner, George, President, Advanced Systems, The Boeing Company, presentation to USAF Energy Forum, Arlington, VA, 8 March 2007.
National Academy of Engineering, "Greatest Engineering Achievements of the 20th Century," http://www.greatachievements.org/ (accessed 1 March 2007).
National Research Council of the National Academies, *Improving the Efficiency of Engines for Large Nonfighter Aircraft,* The National Academies Press, Washington, D.C., Prepublication Draft, Jan 31, 2007.
Office of the Assistant Secretary of the Navy (Research, Development and Acquisition), *Future Fuels,* Naval Reasearch Advisory Committee Report, Washington, D.C., April 2006.

Office of the Secretary of Defense, *DOD Renewable Energy Assessment, Final Report*, Report to Congress, 14 March 2005, http://www.acq.osd.mil/ie/irm/irm_library/Final%20Renewable%20Assessment%20Report.pdf (accessed 1 March 2007).

Office of the Secretary of Defense (Program Analysis & Evaluation) (OSD (PA&E). "Burdened Cost of Fuel," Power Point presentation, 29 November 2006.

Parfomak, Paul W., *Pipeline Safety and Security: Federal Programs*, CRS Report for Congress, Congressional Research Service, Library of Congress, October 11, 2006, http://ncseonline.org/NLE/CRS/abstract.cfm?NLEid=1615 (accessed 13 March 2007).

Peterson, Maj Gen Q. L. HQ AMC/A3, McMahon, Brig Gen R. H. HQ AMC/A4. To AMC OG/CCs and MXG/CCs. Memorandum, 1 December 06.

Pudas, Terry, "A Strategic Approach to Energy," *Defense Technology International*, May/June 2006, http://www.oft.osd.mil/energy/docs/A%20Strategic%20Approach%20To%20Energy-Pudas.pdf (accessed 20 March 2007).

Sandia National Laboratories, DOD Solar Energy Assessment, 2003, http://www.sandia.gov/pv/docs/PDF/Symposium2003/Black.pdf (accessed 1 February 2007).

Schein, Edgar H., *Organizational Culture and Leadership,* Jossey-Bass, San Francisco, CA, 2004.

Schmidt, Michael, "A Reluctant Pentagon Viewed as Key to Fuels Shift," *Platts Inside Energy*, McGraw-Hill Companies, Inc., 9 October 2006.

Siciliano, John, "CTL Proponents, Big Oil Play Up Fischer Tropsch as Alternative Fuel," *Energy Washington Week*, 11 October 2006.

Society of Petroleum Engineers. "How Much Oil and Natural Gas is Left?" http://www.spe.org/spe/jsp/basic/0,,1104_1008218_1109511,00.html (accessed 1 March 2007).

Stricker, Jeffrey M., Chief Engineer, Turbine Engine Division, Propulsion Directorate, Air Force Research Laboratory, "Efficient/Adaptive Cycle Engines," Power Point presentation to the USAF Energy Forum, Arlington, VA, 8 March 2007.

Trimble, Stephen, "US DOD Launches Quest for Energy Self-Sufficiency," *Jane's Defense Weekly*, 43 Issue 39, (27 September 2006): 5.

Tri-Service Renewable Energy Committee Project Listing, http://www.acq.osd.mil/ie/irm/Energy/renew_energy/Air%20Force%20Sep%2003.htm (accessed 20 February 2007).

US Government Accountability Office (GAO), "Geothermal Energy: Information on the Navy's Geothermal Program," GAO-04-513, http://www.gao.gov/new.items/d04513.pdf (accessed 20 February 2007).

US House of Representatives. *Alternative Energy and Energy Efficiency: Hearings before the Subcommittee on Terrorism, Unconventional Threats and Capabilities, and Subcommittee of Readiness Committee on Armed Services*, prepared statement by Michael A. Aimone, 109th Cong. 2d sess., 26 September 2006.

US House of Representatives. *Hearings before the Subcommittee on Terrorism, Unconventional Threats and Capabilities, and Subcommittee of Readiness Committee on Armed Services*, joint statement by John J. Young Jr., and Philip W. Grone, 109th Cong. 2d sess., 26 September 2006.

US House of Representatives. *Policy Issues for Alternative Fuels for Military Operations: Hearings before the Subcommittee on Terrorism, Unconventional Threats and Capabilities, and Subcommittee of Readiness Committee on Armed Services,* prepared statement by James T. Bartis, 109th Cong. 2d sess., 26 September 2006.

US Senate. *Energy Diplomacy and Security: a compilation of statements by witnesses, Committee on Foreign Relations*, prepared statement by Milton R. Copulos, 109th Cong., 2nd sess. (June 2006), 46.

White House. *The National Security Strategy of the United States of America*. Washington D.C, 16 March 2006.

Wynne, Michael W., "Letter to Airmen: Air Force Smart Operations 21," 8 March 2006, http://www.af.mil/shared/media/document/AFD-070205-087.pdf (accessed 19 February 2007)

Wynne, Michael W., Secretary of the Air Force. Address. USAF Energy Forum, Arlington, VA, 8 March 2007.

Yanarella, Ernest J. and William C. Green, *The Unfulfilled Promise of Synthetic Fuels; Technological Failure, Policy Immobilism, or Commercial Illusion*, New York, Westport Connecticut, London, Greenwood Press, 1987.